DEUTSCHE internationale Zeitschrift

für zeitgenössische Wissenschaft

№118
2025

DIZZW 2020

DEUTSCHE internationale Zeitschrift
für zeitgenössische Wissenschaft

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DEUTSCHE internationale Zeitschrift
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ISSN (Print) 2701-8369
ISSN (Online) 2701-8377

Deutsche internationale Zeitschrift für zeitgenössische Wissenschaft

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№118 2025

Deutsche internationale Zeitschrift für zeitgenössische Wissenschaft ist eine internationale Fachzeitschrift in deutscher, englischer und russischer Sprache.

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German International Journal of Modern Science

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№118 2025

German International Journal of Modern Science is an international, German/English/Russian/Ukrainian language, peer-reviewed journal.

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Artmedia24

Anschrift: Industriestraße 8,74589 Satteldorf Deutschland.

E-mail: info@dizzw.com
WWW: www.dizzw.com

Chefredakeur: Reinhardt Roth

Druck: Einzelfirma Artmedia24, Industriestraße 8,74589 Satteldorf Deutschland

Artmedia24

Address: Industriestrasse 8,74589 Satteldorf Germany.

E-mail: info@dizzw.com
WWW: www.dizzw.com

Editor in chief: Reinhardt Roth

Printing: Artmedia24, Industriestrasse 8,74589 Satteldorf Germany.

Der Redaktionsausschuss der Zeitschrift ist nicht verantwortlich für die veröffentlichten Materialien.

Für den Inhalt der Artikel sind die Autoren verantwortlich
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Bei Nachdrucken muss die Zeitschrift zitiert werden.

Das Material wird im eigenen Wortlaut des Autors veröffentlicht.

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In case of materials reprinting - link to journal is required.
Materials are publishing in author's edition.

Edition: № 118/2025 (December) – 118th

Passed in press in December 2025

Printed in December, 2025

Printing: Artmedia 24, Industriestrasse 8,

74589 Satteldorf, Germany.

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AGRICULTURAL SCIENCES

DEVELOPMENT OF ELEMENTS OF WINTER RAPESEED SOWING TECHNOLOGY AS A GREEN MANURE CROP USING AN AGRO-DRONE

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DOI: 10.5281/zenodo.18003042

РОЗРОБКА ЕЛЕМЕНТІВ ТЕХНОЛОГІЇ ПОСІВУ РІПАКУ ОЗИМОГО ЯК СИДЕРАЛЬНОЇ КУЛЬТУРИ ЗА ДОПОМОГОЮ АГРОДРОНУ

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Abstract

In the 21st century, digitalization and automation have become key drivers of agricultural sector development, creating the foundation for the transition to innovative, resource-efficient, and high-technology farming systems. Precision agriculture technologies, particularly the use of unmanned aerial vehicles, have significantly influenced crop monitoring processes, variable-rate application of micronutrients, and plant protection products. However, the use of agro-drones for sowing remains an insufficiently explored direction that requires scientific justification, technical refinement, and adaptation to different soil types, crops, and production conditions. Under wartime circumstances, Ukraine has become one of the global centers for the advancement of unmanned technologies, creating a unique opportunity to integrate innovations from the defense sector into civilian agricultural production.

Анотація

У XXI столітті цифровізація та автоматизація стали визначальними чинниками розвитку аграрного сектора, формуючи передумови переходу до інноваційних, ресурсозберігаючих і високотехнологічних методів ведення землеробства. Технології точного землеробства, зокрема використання безпілотних літальних апаратів, суттєво вплинули на процеси моніторингу стану посівів, диференційованого внесення мікродобрив та засобів захисту рослин. Однак застосування агродронів для сівби й досі залишається малодослідженим напрямом, який потребує наукового обґрунтування, технічного доопрацювання та адаптації до різних типів ґрунтів, культур і виробничих умов. В умовах воєнних дій Україна стала одним із глобальних

центрів розвитку безпілотних технологій, що створює унікальну можливість інтегрувати напрацювання оборонної промисловості у цивільне агровиробництво.

Keywords: agro-drone, precision agriculture, drone-based sowing, winter rapeseed, green manure crops, green manuring, seeding rate, seed distribution uniformity, sowing technology.

Ключові слова: агродрон, точне землеробство, посів з дрона, ріпак озимий, сидеральні культури, сидерація, норма висіву, рівномірність розподілу насіння, технологія посіву.

Аналіз сучасних наукових джерел свідчить про суттєве зростання ролі безпілотних літальних апаратів у технологізації аграрного виробництва, оскільки безпілотні системи дають можливість підвищити точність виконання агротехнічних операцій, зменшити витрати ресурсів та забезпечити стабільність виробництва за умов кліматичних змін [1, 2, 14-16]. Ці дослідження заклали теоретичне підґрунтя для переходу від використання безпілотних літальних апаратів переважно як інструментів дистанційного моніторингу до впровадження повноцінних технологічних операцій, зокрема UAV-sowing - посіву сільськогосподарських культур за допомогою дронів, оснащених автоматизованими системами дозування і розподілу насіння. Саме ця технологія відкриває можливості для аеросівби дрібнонасінних культур, таких як ріпак озимий.

Ряд наукових праць підтверджують, що ріпак озимий є однією з найбільш перспективних культур для посіву з дрона. У дослідженні Huang X. та ін. (2024) експериментально доведено можливість застосування багатороторного агродрона для висіву ріпаку із забезпеченням контрольованої норми та рівномірності розподілу насіння завдяки вдосконаленій системі дозування [3]. Tan X. та ін. (2025) підтвердили ефективність технології UAV-sowing у виробничих умовах: посів ріпаку за допомогою дрону забезпечує повноцінні сходи та оптимальні параметри густоти стояння за умов обмеженого доступу наземної техніки [4]. Дослідження Zhu Y. та ін. (2025) показали, що аеросівба дрібнонасінних культур значною мірою залежить від аеродинамічних характеристик повітряного потоку ротора, висоти польоту та швидкості руху дрона [5], що є особливо актуальним для ріпаку озимого через малу масу насіння та чутливість до рівномірності розміщення. Агрономічні дослідження ріпаку озимого дозволяють окреслити біологічні та технологічні вимоги культури, необхідні для адаптації посівів за допомогою дрону до польових умов. Вивчення особливостей розвитку та перезимівлі ріпаку в різних кліматичних регіонах України засвідчує високу чутливість культури до густоти рослин, інтенсивності осіннього розвитку та строків сівби [6, 7, 14]. Доведено, що дія метеорологічних факторів, зокрема температурного режиму та кількості опадів, істотно впливає на формування біомаси та насіннєвої продуктивності [8].

Особливе значення для сівби із використанням дрону мають дослідження впливу норми висіву та ширини міжрядь. Волощук О. П. та інші автори встановили, що зміна норми висіву ріпаку озимого впливає на структуру врожаю та здатність рослин до компенсації [9]. Ряд публікацій, зокрема дослідження Журавля С. В. підтверджують критичну роль ширини міжрядь, яка визначає густоту стояння та потенціал формування сидеральної маси [10, 14-16]. Вибір міжрядь і густоти стояння є ключовим для налаштування ширини смуги та щільності розподілу насіння при аеросівбі. В наукових дослідженнях також відмічається, що строки сівби значною мірою впливають на зимостійкість, формування кореневої системи й потенційну продуктивність ріпаку озимого [11, 12]. Окремі дослідження, присвячені порівнянню способів сівби, доводять, що ріпак озимий виразно реагує на спосіб внесення насіння та просторову структуру посіву [13, 14-16], що створює наукове обґрунтування для пошуку альтернативних методів висіву, включно з дрон-технологіями.

Отже, результати сучасних досліджень підтверджують, що: технологія UAV-sowing ріпаку озимого має доведену інженерну ефективність [3-5]; агрономічні параметри культури (норма висіву, міжряддя, строки сівби, рівномірність) є критичними для адаптації посіву за допомогою дрону до польових умов [6-16]. Разом із тим у наукових джерелах відсутні комплексні дослідження, які б поєднували інженерно-технологічні параметри аеросівби дроном із агрономічною ефективністю ріпаку озимого як сидеральної культури, що і зумовлює актуальність даної роботи.

Методика проведення досліджень

Дослідження з відпрацювання технології посіву сидеральних культур із використанням агродрону проводилися протягом двох років на науково-дослідному полі Поліського національного університету поблизу села Велика Горбаша Черняхівської селищної територіальної громади Житомирського району Житомирської області (50°26'17" N, 28°41'38" E). Ґрунтовий покрив дослідної ділянки представлений сірими лісовими легкосуглинковими ґрунтами, що характеризуються низьким умістом гумусу, недостатнім забезпеченням основними елементами живлення та підвищеною кислотністю. Перед закладкою досліду було проведено агрохімічне обстеження ґрунту з відбором зразків у шарах 0-10 см, 10-20 см та 20-30 см для визначення pH, вмісту гумусу та рухомих форм азоту, фосфору і калію, з метою встановлення вихідного агрофону, що може впливати на проростання, ріст і розвиток ріпаку озимого. У нашому дослідженні об’єктом виступав озимий ріпак сорту Чорний Велетень, посів якого здійснювали за допомогою агродрону. Відповідно до експериментальної схеми висів проводили при двох нормах: 320 та 560 рослин/м², що відповідало внесенню 16 та 28 кг/га насіння. Застосування підвищених норм висіву порівняно з традиційною сівалкою було обумовлене шнековим типом висівного апарату дрону, а також відсутністю механічного загортання та необхідністю

забезпечення більшої густоти стояння для формування рівномірного рослинного покриву.

Методика досліджень передбачала три етапи. На підготовчому етапі виконували лабораторну оцінку насіннєвого матеріалу, визначали його схожість та енергію проростання, проводили вибір дослідної ділянки та її розмітку з урахуванням розташування варіантів і повторностей. Для попередньої оцінки однорідності ділянки було здійснено NDVI-картування за супутниковими даними Sentinel-2 у програмному середовищі ArcGIS Pro (ESRI). Отримані дані підтвердили відсутність значних контрастів у продуктивності ґрунту, що дозволило рівномірно розмістити варіанти досліду. Для забезпечення точності просторової прив'язки польових спостережень використовували RTK GNSS-приймач Hi-Target V30Plus, який також застосовували для синхронізації аерофотознімків з наземними вимірюваннями.

Основний етап передбачав апробацію двох варіантів підготовки площі - за гліфосатною та безгліфосатною технологіями. Для внесення гербіциду використовували агродрон MC A22, який працював із нормою препарату 2 л/га та робочою нормою виливу 7,5 л/га за висоти польоту 4 м, швидкості 8 м/с і швидкості вітру 2 м/с при напрямку A338°. Посів ріпаку озимого здійснювали агродроном XAG P100 Pro у трикратній повторності. Перед сівбою проводили калібрування висівного апарата для забезпечення стабільної подачі насіння. Сівба виконувалася за сприятливих погодних умов: температура повітря становила +22,6 °C, відносна вологість - 60 %, швидкість вітру - 1,1 м/с. Такі параметри забезпечували рівномірність розподілу насіння і мінімізацію впливу турбулентних потоків ротора.

Результати досліджень

У межах підготовчого етапу було проведено лабораторну оцінку посівних якостей насіння ріпаку озимого сорту Чорний Велетень, оскільки цей показник є ключовим при впровадженні технології посіву агродроном. На відміну від традиційних ґрунтообробних та посівних машин, які забезпечують загортання насіння на оптимальну глибину, під час проведення посіву за допомогою дрону насіння ріпаку залишається на поверхні ґрунту або частково потрапляє у мікротріщини, де піддається впливу низки абіотичних і біотичних чинників. До таких належать: коливання температури та вологості верхнього ґрунтового шару, ризик пересихання під дією сонячної радіації, вітрова ерозія, а також можливе поїдання дрібними птахами. За цих умов успішність проростання більшою мірою залежить від внутрішнього фізіологічного потенціалу насіння, зокрема від показників енергії проростання та лабораторної схожості. Це робить визначення насіннєвих кондицій одним із базових елементів експерименту.

Лабораторний дослід по визначенню конденційних показників насіння ріпаку проводився в трьохкратній повторності та засвідчив високі біометричні, фізіологічні якості насіннєвого матеріалу (табл. 1). Середнє значення енергії проростання становило 92,7 %, а лабораторної схожості — 94,0 %, що перевищує мінімальні стандартні вимоги для посівного матеріалу озимого ріпаку (не менше 85–90 %). Висока енергія проростання свідчить про активні процеси водопоглинання зародком і швидке формування первинних корінців та сім'ядоль, що є критично важливим за умов поверхневого розміщення насіння при посіві дроном. Високий рівень лабораторної схожості забезпечує стабільність формування початкової густоти — одного з ключових параметрів продуктивності ріпаку озимого, особливо коли культура використовується як сидеральна.

Таблиця 1

Насіннєві кондиції насіння ріпаку озимого сорту Чорний Велетень за результатами лабораторного досліду (n=3)

Культура	Енергія проростання, %				Схожість, %			
	I	II	III	Середнє	I	II	III	Середнє
Winter rapeseed (ріпак озимий, сорт Чорний Велетень)	88	94	96	92,7	92	96	98	94,0

Отримані результати дали можливість оптимізувати норму висіву, яка зазвичай застосовується при прямому розсіюванні насіння без загортання. При цьому подальші дослідження були спрямовані саме на оцінку технологічних факторів (норма висіву, висота польоту агродрона, параметри висівного апарата), не роблячи похибку щодо якісних показників насіннєвого матеріалу.

Наступним етапом стало визначення рівномірності просторового розподілу насіння при посіві за допомогою дрону, оскільки цей показник є критично важливим для формування однорідного агрофітоценозу ріпаку. У межах досліду проводили аналіз фактичної кількості насінин на одиницю площі (1 м²), визначали коефіцієнт варіації, що характеризує стабільність та рівномірність розподілу, а також оцінювали вплив норми висіву на структуру посіву. Особливу увагу приділяли тому, що ріпак озимий є культурою з високою чутливістю до густоти стояння, а надмірна нерівномірність може спричинити локальне зрідження посівів або надмірне загущення, що в обох випадках знижує потенціал формування біомаси.

Отримані результати польових досліджень (табл. 2) засвідчили наявність вираженої нерівномірності просторового розподілу насіння ріпаку озимого при аеросівбі, що проявлялося як у варіації фактичної густоти в межах посівної смуги, так і у зміщенні частини насіння за її межі. Аналіз показав

істотний вплив траєкторії руху дрона та висоти польоту на характер розподілу, що є типовим явищем для поверхневого висіву дрібнонасінних культур. Найвище накопичення насіння спостерігалося безпосередньо в зоні проходу дрона (0 м від умовної лінії руху), де при нормі висіву 320 шт насінин на 1 м² було зафіксовано 98 шт/м² за висоти польоту 3 м та 80 шт/м² за висоти 5 м. Водночас зі збільшенням відстані на 1,5 м показники істотно зменшувалися або, навпаки, збільшувалися залежно від напрямку аеродинамічних потоків, що формуються під час руху багатороторного апарата. Наявність таких «провальних» та «ущільнених» зон свідчить про зміщення частини насіння під дією повітряних вихорів, індукованих роторною системою.

За висоти польоту 3 м фактична середньозважена густота для норми 320 рослин/м² становила 79 шт/м² (24,8 % від розрахункової норми), тоді як при висоті 5 м вона знижувалася до 58 шт/м² (18,1 %). Це підтверджує закономірність: збільшення висоти польоту знижує точність розподілу насіння через більш виражений вплив турбулентних потоків та горизонтального дрейфу.

Таблиця 2

Розподіл насіння ріпаку озимого по ділянці залежно від траєкторії руху дрона, 2025

Культура	Проєктивна густота, рослин/м²	Висота висіву насіння, м	Відстань від умовної лінії проходу дрона, м			Середньозважений показник висіяного насіння, шт/м²	% від запланованої норми
			0	1,5	3		
			Кількість насінин, шт/м²				
Ріпак озимий	320	3	98	104	36	79	24,8
		5	80	52	42	58	18,1
	560	3	398	204	36	213	38,0
		5	227	331	36	198	35,4

Аналогічна тенденція характерна і для підвищеної норми висіву (560 рослин/м²), де середньозважене значення склало 213 шт/м² (38,0 %) за висоти 3 м та 198 шт/м² (35,4 %) за висоти 5 м. Водночас значні коливання по відстанях (398 → 204 → 36 шт/м² та 227 → 331 → 36 шт/м²) вказують на порушення симетрії посіву та формування локальних зон надмірної або недостатньої густоти. Виявлені відхилення пояснюються аеродинамічною поведінкою насіння ріпаку озимого, яке є легким і схильним до зміщення під впливом повітряних потоків. Особливо суттєвим є ефект вихрових зон позаду дрона, які створюють нерівномірний розподіл горизонтальної сили, що переносить частину насіння убік від лінії проходу.

Таким чином, результати досліджень підтверджують, що при сівбі ріпаку озимого методом аеророзсіювання зростає ризик асиметрії посіву, що призводить до нерівномірного формування агрофітоценозу та неоднорідності густоти стояння. Це, у свою чергу, знижує накопичення біомаси і потенціал сидерації у разі надто нерівномірного покриття ґрунту рослинністю. У зв'язку з цим доцільним є використання перехресної сівби (cross-seeding), коли дрон здійснює два перпендикулярні проходи з половинною нормою висіву. Така технологія компенсує асиметрію розподілу, сприяє рівномірному формуванню густоти рослин, зменшує локальну конкуренцію за світло, вологу й елементи живлення, а також покращує загальну структуру агрофітоценозу. Крім того, перехресний посів значною мірою зменшує бокове знесення насіння, оскільки компенсує односторонній дрейф насінин зустрічними потоками двох ортогональних прольотів.

З огляду на результати досліджень можна стверджувати, що для підвищення якості сівби ріпаку озимого за допомогою дрону необхідною є технологічна адаптація висівних систем агродронів, зокрема: удосконалення механізмів дозування, оптимізація висоти польоту, модифікація траєкторій руху та впровадження адаптивних алгоритмів розподілу. Це дозволить забезпечити агрономічно виправдану густоту стояння, стабільність біометричних показників і підвищити ефективність використання ріпаку озимого як сидеральної культури. Наступним етапом досліджень був польовий моніторинг росту та розвитку рослин ріпаку озимого з метою визначення впливу технології підготовки ґрунту, норми висіву та висоти польоту дрона на формування стабільної густоти стояння. На відміну від традиційної ґрунтозахисної сівби, де насіння загортається у вологий шар і захищене від абіотичних стресів, при сівбі за допомогою дрону насіння розташовується на поверхні ґрунту, що підвищує ризик його пересихання, втрати капілярної вологи та нерівномірності появи сходів. Тому саме фактична густота та виживабельність проростків є визначальними індикаторами якості виконання технологічної операції.

Отримані дані (табл. 3) засвідчили суттєві відмінності між варіантами досліду. Найнижчі показники польової схожості та збереженості рослин фіксувалися на ділянках без застосування гербіцидної підготовки ґрунту. При проєктивній густоті 320 рослин/м² кількість рослин на момент оцінювання становила лише 1,39 шт/м² за висоти посіву 3 м та 1,62 шт/м² за висоти 5 м, що відповідає 0,43–0,51 % від висіяного насіння. Така низька виживабельність зумовлена високим конкурентним тиском бур'янів,

які швидше проростають на поверхні ґрунту і пригнічують рослини ріпаку на ранніх фазах органогенезу. При підвищеній нормі висіву (560 рослин/м²) у варіанті без гліфосату виживабельність залишалася критично низькою — лише 0,62–1,72 %, а коефіцієнт варіації досягав 214,24 %, що вказує на сильну локальну нерівномірність та випадання частини рослин через загущення. Застосування гліфосату на передпосівному етапі істотно покращило умови для формування сходів ріпаку озимого. У варіанті 320 рослин/м² кількість збережених рослин зросла до 14,47 шт/м² (4,52 %) при висоті польоту 3 м і до 21,99 шт/м² (6,87 %) при висоті 5 м. Вирівнювання рослинного покриву стало можливим завдяки зменшенню конкуренції з боку бур'янів у період проростання та формування першої пари справжніх листків — найбільш критичній фазі для озимого ріпаку.

Таблиця 3

Вплив технології, норми висіву та висоти посіву з дрона на залишкову кількість рослин ріпаку озимого, шт/м^2

Варіант (технологія вирощування)	Проєктивна густота, рослин/м^2	Висота висіву насіння, м	Середнє по повторенням, шт/м^2			Середнє по варіанту	Коефіцієнт варіації, %	Виживабельність рослин на 1 м^2, %
			0	1,5	3			
Без гліфосату	320	3	1	1	2	1,39±1,73	124,37	0,43
		5	0	1	4	1,62±3,42	211,05	0,51
	560	3	0	1	9	3,47±7,44	214,24	0,62
		5	8	8	13	9,61±6,67	69,38	1,72
Обробка гліфосатом	320	3	11	13	19	14,47±10,69	73,90	4,52
		5	23	16	27	21,99±11,18	50,82	6,87
	560	3	9	6	13	9,61±4,47	46,57	1,72
		5	5	8	11	8,1±4,74	58,49	1,45

При нормі висіву 560 рослин/м² на оброблених ділянках виживабельність була дещо вищою порівняно з контролем (1,45-1,72 %), однак залишалася значно нижчою, ніж у варіанті з меншою нормою. Це свідчить про те, що надмірне загущення при поверхневому висіві посилює внутрішньовидову конкуренцію, призводить до вилягання проростків, порушує фотосинтетичну активність і значною мірою знижує шанси рослин на виживання. Загалом встановлено, що оптимальною комбінацією технологічних рішень є гербіцидна підготовка площі перед посівом, норма висіву 320 рослин/м² та висота польоту дрона 5 м. У цьому варіанті формувалася найвища фактична густота стояння рослин серед усіх досліджених комбінацій, а структура посіву була більш рівномірною та стабільною в межах облікових ділянок.

Отримані результати свідчать, що рівномірний розподіл рослин на початкових етапах розвитку є критично важливим для озимого ріпаку, оскільки культура потребує достатньої площі живлення, оптимального світлового режиму та збалансованого формування листкової розетки. Саме рівномірність розміщення рослин визначає їхню здатність до ефективного нагромадження вегетативної маси, розвитку потужної кореневої системи, що зумовлюють успішне використання озимого ріпаку як сидеральної культури та його потенціал у збагаченні ґрунту органічною речовиною.

Висновки. У ході дослідження було опрацьовано можливості застосування агродронів для посіву ріпаку озимого сорту Чорний Велетень як перспективної сидеральної культури. Посів виконували дроном XAG P100 Pro, оснащеним шнековим висівним апаратом, що забезпечувало можливість контролю висіву та проведення польових випробувань за різних технологій. Моніторинг польового посіву показав наявність технологічних обмежень, пов'язаних із фізичними властивостями насіння та особливостями аеродинамічних потоків дрона. Зокрема, встановлено нерівномірність розподілу насіння по поверхні ґрунту та часткове зміщення насінин за межі облікових ділянок. Це обумовлено турбулентністю повітря під час польоту та відсутністю механічного загортання насіння у ґрунт, що характерно для аеросівби дрібних олійних культур. Такі результати свідчать про необхідність удосконалення алгоритмів розсіювання, оптимізації конструкції висівного апарата та налаштувань польоту дрона для забезпечення більш рівномірного факела висіву.

На основі проведених спостережень найбільш технологічно доцільним рішенням для підвищення рівномірності висіву ріпаку озимого є впровадження перехресного посіву з половинними нормами висіву, що суттєво підвищує однорідність покриття площі та зменшує внутрішньовидову конкуренцію між рослинами. Такий підхід сприяє формуванню більш стабільного сидерального покриву, здатного ефективно накопичувати фітомасу та пригнічувати ріст бур'янів. Результати польових досліджень засвідчили, що вихід життєздатних рослин ріпаку озимого суттєво варіював залежно від варіанта підготовки ґрунту, норми висіву та висоти польоту дрона. Найвищі показники збереженості рослин і найкраща структура посіву були отримані у варіанті з гербіцидною підготовкою площі, нор-

мою 320 рослин/м² та висотою висіву 5 м, де виживабельність становила близько 6,87 %. У варіантах без застосування гербіциду збереженість рослин була значно нижчою, що вказує на важливе значення контролю бур'янів для успішного формування сходів при поверхневому розміщенні насіння.

Таким чином, ріпак озимий продемонстрував достатній рівень адаптивності для використання в технологіях посіву з агродронів, проте ефективність формування посіву значною мірою залежить від рівномірності розподілу насіння, підготовки площі та оптимально підібраної норми висіву. Отримані результати обґрунтовують необхідність подальшої розробки спеціалізованих висівних систем для агродронів, удосконалення схем польоту, а також проведення додаткових досліджень щодо оптимізації норм висіву та адаптації технології для різних ґрунтово-кліматичних умов України.

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ARTS

MUSIC AND LITERACY: EXAMINING THE EFFECTS OF MUSIC INSTRUCTION ON READING SKILLS IN ELEMENTARY SCHOOL

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Abstract

This study explores the relationship between music instruction and the development of reading skills among elementary school students. Drawing on recent research in cognitive psychology and early childhood education, the article examines how musical activities—such as rhythm exercises, singing, and structured instrumental training—support foundational literacy abilities. Music instruction is shown to enhance phonological awareness, auditory discrimination, and memory, all of which are essential components of early reading success. Additionally, rhythmic patterns and melodic structures help children recognize syllables, improve pacing, and strengthen language processing. Classroom observations and comparative assessments indicate that students who participate in regular music programs often demonstrate stronger decoding skills, higher reading fluency, and greater overall engagement in literacy tasks. The findings suggest that integrating music into the elementary curriculum can provide a meaningful and motivating pathway for improving reading outcomes. The article concludes by highlighting implications for educators and recommending further interdisciplinary research.

Keywords: Music instruction, reading skills, phonological awareness, elementary education, literacy development

İntroduction

The early years of schooling play a crucial role in shaping a child's language and literacy abilities. While traditional reading instruction focuses on phonics, vocabulary building, and comprehension, growing attention has been given to the role of arts-based learning—particularly music—in supporting these skills. Music instruction engages children in activities that develop listening, rhythm, memory, and sound discrimination, all of which closely relate to the processes involved in learning to read. In many elementary classrooms, teachers observe that students who participate in musical activities become more attentive listeners and more confident readers. This connection has encouraged researchers to explore how rhythm, melody, and musical structure may strengthen phonological awareness, reading fluency, and overall language development. The present study examines these relationships in greater depth, aiming to understand how music instruction contributes to improvements in reading skills and why it may serve as a valuable component of a well-rounded elementary education. The early years of schooling shape the foundations of a child's academic life, and among the most important of these foundations is literacy. Reading skills—such as phonological awareness, decoding, fluency, vocabulary development, and comprehension—play a central role in a child's ability to succeed in other subjects and communicate effectively. While educators have long relied on structured reading programs to support literacy, growing attention has been given to the role of arts-based learning, particularly music instruction, in strengthening early reading skills. Music, traditionally seen as an enrichment activity, is increasingly recognized as a powerful educational tool that influences cognitive, emotional, and social development. Its connection with language, rhythm, and listening skills suggests that music may play an active role in enhancing literacy, especially for elementary school children. Music is a multisensory experience. When children sing, clap rhythms, play simple instruments, or listen attentively to melodies, they engage several areas of their brain simultaneously. These activities promote auditory discrimination, pattern recognition, memory, attention, and coordination. All of these are essential components of early reading development. In many classrooms, teachers have observed that children who participate regularly in music lessons tend to grasp language-related tasks more easily. The reason lies in the nature of music itself—its rhythm, repetition, structure, and emotional appeal make it a natural companion to early literacy learning [6].

One of the strongest connections between music instruction and reading development lies in phonological awareness. This skill involves recognizing and manipulating the individual sounds within words. Children who can detect rhymes, clap syllables, identify beginning sounds, and separate phonemes typically learn to read with greater ease. Musical activities naturally strengthen these abilities. When children clap along to a beat or repeat rhythmic patterns, they are training their ears to hear differences in sound duration, intensity, and pitch. This sensitivity helps them detect the subtle sound distinctions necessary for decoding new words. Rhyming songs, chants, lullabies, and call-and-response activities further reinforce sound patterns in ways that feel effortless and enjoyable [5].

Memory is another cognitive domain shaped by music. Songs and melodies tend to stay with children longer than spoken sentences or lists of information. As children learn lyrics, they internalize new words, grammatical structures, and narrative sequences. This strengthens both short-term and long-term memory—skills crucial for reading comprehension and fluency. A

child who can remember a sequence of musical notes or song verses is more likely to remember sight words, sentence structures, and story elements during reading tasks. Teachers often observe that children with strong musical habits have an easier time recalling phonics rules, spelling patterns, and vocabulary meanings [3].

In addition to cognitive benefits, music also influences emotional development and classroom motivation. Elementary school children learn best when they are engaged and enjoying the learning process. Music naturally motivates them because it brings movement, energy, and expression into the classroom. Singing together builds a sense of belonging, and rhythm games encourage participation without fear of being wrong. For children who struggle with reading, this emotional boost is especially important. Music creates a supportive environment where learning feels less intimidating. A child who is hesitant to read aloud may happily participate in musical storytelling or rhythm activities, gradually building confidence that later carries over into reading lessons.

Reading fluency—the ability to read smoothly, accurately, and with proper expression—is another area where music plays an influential role. Fluency requires pacing and rhythm, both of which are developed through musical practice. Students who can follow a steady beat or maintain a rhythmic pattern tend to read with better phrasing and natural flow. Activities such as chanting poems, singing simple melodies, or reading along with rhythmic background music help children internalize speech patterns. This internal rhythm supports not only fluency but also comprehension, because smooth reading frees mental space for understanding the text [4].

The social benefits of music instruction also indirectly support literacy. Music often involves group participation, cooperation, and listening to others. These interactions teach important social communication skills that improve classroom behavior and readiness for academic tasks. When children participate in musical group work, they learn to wait for their turn, follow instructions, and respond appropriately—all behaviors that contribute to successful literacy activities such as shared reading, partner reading, and group discussions.

Integrating music into the elementary school curriculum does not mean replacing reading instruction. Rather, music enriches and enhances it. Teachers can incorporate music in simple yet effective ways: beginning the day with a song, introducing new vocabulary through melody, clapping syllables of spelling words, using rhythm sticks during reading warm-ups, or adding musical elements to storytelling. Even short musical breaks help refocus children, giving them renewed attention for reading tasks. In classrooms where music is part of daily routines, children often show greater enthusiasm for learning, improved concentration, and increased confidence [2].

The relationship between music and literacy also raises an important point about educational balance. In some schools, pressure to improve standardized test scores has led to reduced time for arts programs. However, evidence suggests that music supports academic growth rather than distracts from it. Children develop as whole learners, and music contributes to their intellectual development in ways that traditional lessons alone cannot achieve. By training the brain in rhythm, listening, expression, and pattern recognition, music builds a stronger foundation for literacy.

Research continues to highlight the lasting impact of early music instruction. Children exposed to consistent musical activities in elementary school often maintain better reading outcomes in later grades. They tend to show stronger phonics skills, better verbal memory, improved vocabulary, and greater reading fluency. Even after differences in socioeconomic background, learning environment, and teaching quality are accounted for, music instruction remains a meaningful predictor of literacy success. Beyond its immediate academic benefits, music instruction helps cultivate habits and mindsets that continue to support children throughout their educational journey. When students engage with music, they learn discipline through practice, patience while mastering new skills, and perseverance when faced with challenges. These qualities mirror the attitudes required for successful reading development, where progress often relies on gradual improvement and sustained effort. Music also encourages creativity, allowing children to express themselves freely and approach problems with flexibility—skills that enrich reading comprehension and critical thinking. As children combine musical learning with literacy activities, they develop a deeper sense of curiosity about language and storytelling. This curiosity fuels a stronger connection to books, motivating them to explore texts more independently. In this way, music serves not only as a complement to reading instruction but as an essential part of nurturing well-rounded, motivated learners who view literacy as an exciting and meaningful part of their lives [1].

In considering the broader implications of music's influence on literacy, it becomes clear that integrating music into elementary education is more than an instructional technique—it reflects a philosophy of teaching the whole child. When children experience learning through sound, movement, repetition, and emotion, they form stronger neural connections that support long-term understanding. Music encourages them to listen carefully, interpret meaning, and respond thoughtfully, all of which are cornerstones of effective reading. It also provides a structured yet flexible environment where children can explore language in playful and engaging ways. For many students, this multisensory approach opens pathways that traditional literacy methods do not always reach. As a result, music becomes a powerful equalizer, offering diverse learners—whether advanced, struggling, or learning a second language—an accessible route into the world of reading. By embracing this connection, schools can create richer, more inclusive classrooms that empower children to develop both their academic and creative potential [3].

Conclusion

The evidence gathered from classrooms, cognitive studies, and educational observations demonstrates that music instruction offers far more than artistic enrichment; it plays a meaningful and measurable role in

strengthening children's reading development. Through rhythm, melody, repetition, and active listening, music supports the very skills that early readers rely on—sound awareness, decoding, memory, fluency, and language comprehension. These connections show that music is not a separate or unrelated subject but rather an integrated learning tool that reinforces core literacy principles in a natural and engaging way. Music also contributes to a positive emotional climate in the classroom. Children who feel motivated, confident, and included are more willing to take risks during reading activities. Musical learning provides exactly this kind of environment. It reduces stress, increases attention, builds social cooperation, and helps even reluctant readers participate meaningfully. For students who struggle academically, music can serve as a bridge, guiding them toward greater confidence and improved learning outcomes.

As educational systems worldwide seek new ways to improve literacy achievement, it is increasingly important to recognize the role that arts-based instruction can play. Rather than limiting music programs, schools may benefit from expanding them, integrating musical activities into daily reading routines, and training teachers to use music strategically in literacy instruction. This approach does not replace traditional reading lessons but enhances them, offering a richer, more balanced educational experience.

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BIOLOGICAL SCIENCES

MORPHOMETRIC CHARACTERISTICS OF RUDD (SCARDINIUS ERYTHROPHTHALMUS) DISTRIBUTED IN ULLISHORKUL LAKE, KHOREZM REGION

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Abstract

This article examines the morphometric characteristics of the Scardinius erythrophthalmus (rudd) population sampled from Ullisho‘rko‘l Lake in Khorezm Region. During the study, statistical evaluation was conducted on the main morphological traits (l, c, ao, o, hc, H, fin lengths and distances) of body and head proportions in 25 individuals. The results revealed overall stability of body proportions in the population, alongside moderate phenotypic variability in the head segment (hc/c) and certain fin characteristics. The average body length of 196.04 ± 2.97 mm and the coefficient of variation for most traits remaining within the 3–9 % range confirm the morphometric homogeneity of the population. Relatively higher variability in the head region is explained by differences in ecological conditions and age groups. The obtained data provide an important scientific basis for assessing the ecological adaptability, population structure, and biological status of this species in the water body.

Keywords: Scardinius erythrophthalmus, morphometrics, statistical analysis, population structure, Ullisho‘rko‘l Lake, ecological adaptability.

Introduction

Ullisho‘rko‘l Lake is the largest natural lake in the Khorezm Region of the Republic of Uzbekistan. It is located 14 km southeast of the city of Khiva. The southern part of the lake extends into the territory of Turkmenistan. The total area of Ullisho‘rko‘l Lake is 14.8 km², its elevation is 86 m above sea level, its length from north to south is 16 km, and its width reaches 4 km. The lake is mainly fed by collector-drainage waters and excess irrigation water flowing from fields in its northern part (National Encyclopedia of Uzbekistan, 2005).

Scardinius erythrophthalmus (Linnaeus, 1758) is a freshwater fish species widely distributed in Europe and Central Asia. Although this species has limited direct commercial value, it plays an important role as a food source for predatory fish inhabiting freshwater ecosystems (Özgür Emiroğlu, 2010).

The species is typically found in slow-flowing rivers, lakes, and reservoirs, showing good adaptation to environments rich in aquatic vegetation. The rudd exhibits feeding habits that can vary depending on temperature and season. In general, its diet includes various aquatic plants along with small animal organisms and detritus (Nurminen et al., 2003). The feeding intensity of rudd is positively correlated with water temperature (Kapuscinski et al., 2012).

Morphometric parameters of Scardinius erythrophthalmus specimens collected from the Shumarovka River and Chistoye Lake in Russia have been studied, and their morphometric characteristics were compared (A.S. Mavrin et al., 2017). In the freshwater river systems of Arkhangelsk Province, Russia, coefficients of variation were examined for the overall populations of Scardinius erythrophthalmus aged 1+ to 4+. The results revealed considerable variability in growth-related traits such as maximum and minimum body height, total length, and standard length of the fish (M. Klymenko et al., 2022).

Analysis of morphometric characteristics of fish remains one of the most reliable research methods in ichthyology, a technique that has been applied for many years and still retains its relevance today.

Continuation of the translation:

Studying the morphometric characteristics of Scardinius erythrophthalmus makes it possible to determine the population structure, biological features, and ecological adaptability of this species. Its body structure, fins, and relative dimensions of the head may exhibit variability depending on environmental conditions. Moreover, these data have important scientific and practical significance for fisheries management, rational use of natural resources, and the conservation of biodiversity.

The purpose of our research is to determine the morphometric indices of Scardinius erythrophthalmus relative to body and head length and to highlight their biological and ecological importance.

Materials and Methods

Research on Scardinius erythrophthalmus was conducted in August 2025 in Ullisho‘rko‘l Lake, Khorezm Region. The species composition of the caught fish was identified using the guides of Berg (1948) and Mirabdullayev (2011). Collection of material in the study area was carried out according to generally accepted ichthyological methods (Pravdin, 1966). As a result of the research, 25 specimens of rudd (Scardinius erythrophthalmus) were collected from the lake. The length and weight of the fish were measured,

and morphometric characteristics were determined (Pravdin, 1966).

In the statistical analysis of morphometric traits, the following parameters were calculated: range (Lim), mean (M) and its error (m), standard deviation (σ), variance, coefficient of variation (Cv %), and differences between traits (Lakin, 1990).

The exact locations where fish samples were caught in the study area were recorded, and geographic coordinates were determined (Table 1).

Table 1

Coordinates of the catching locations of Scardinius erythrophthalmus

Sampled area	Coordinate points	Width (°)	Length (°)
Lake Ullishorkul	41°15′45.95″N 60°28′54.63″E	41.26276	60.48184
	41°15′44.03″N 60°29′05.06″E	41.26223	60.48474
	41°15′39.54″N 60°28′43.46″E	41.26098	60.47874
	41°15′25.54″N 60°28′58.7″E	41.25709	60.48297
	41°15′18.98″N 60°29′12.1″E	41.25527	60.48669

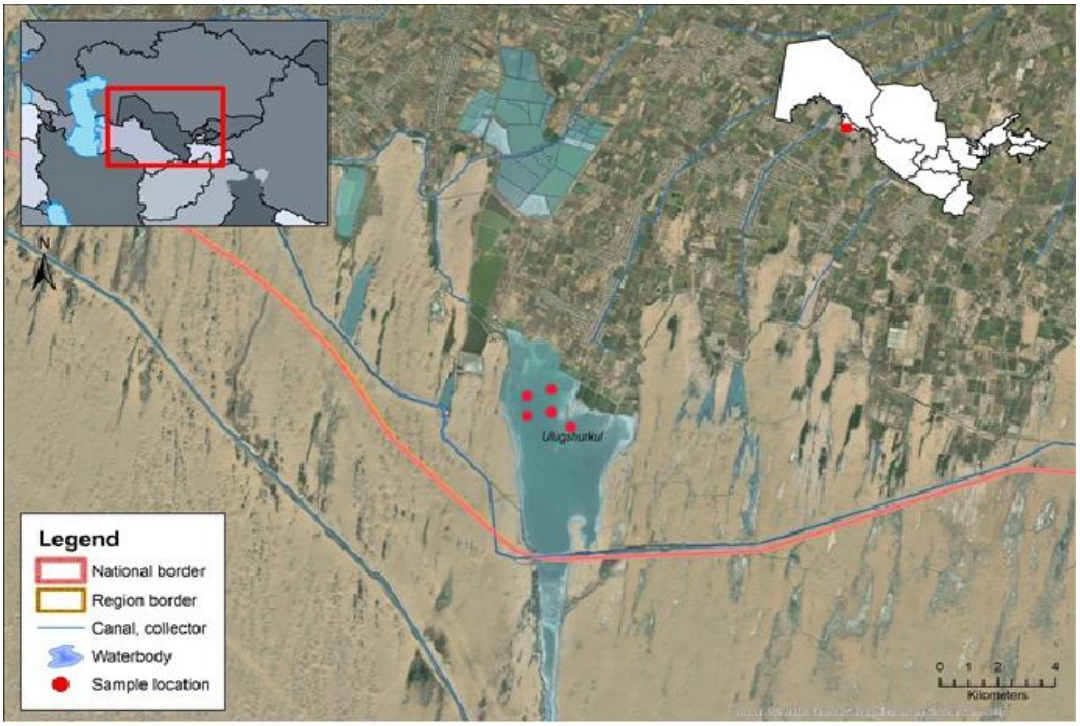

Figure 1. *General view of Ullisho‘rko‘l Lake located in Khorezm Region (Republic of Uzbekistan) and the points where fish samples were collected.*

Continuation of the translation:

The coordinates obtained from Ullisho‘rko‘l Lake confirm that rudd is distributed throughout the entire lake and demonstrate the ecological diversity of the population. These data increase the reliability of the morphometric analysis results and provide a scientific basis for studying the spatial structure of the population. The material collected on the basis of these coordinates was analyzed, and the morphometric characteristics of the fish caught in the area were determined.

Results and Discussion

The morphometric characteristics of the studied fish were statistically analyzed.

Relative to body length (standard length, l):

The average body length (l) was 196.04 ± 2.97 mm, with a coefficient of variation (Cv) of 7.58%. This indicates moderate variation in body length within the population.

Snout length (Ao) (4.68 ± 0.07%) and eye diameter (O) (4.27 ± 0.04%) showed small values, with relatively low variation (Cv = 4.90–7.93%).

For the majority of traits, the coefficient of variation ranged between 3–9%, which indicates stability of morphometric characteristics in the population (Table 2).

Relative to head length (c):

Head length (hc/c) showed the highest value at 16.30 ± 0.32%, with a coefficient of variation of 9.75%, indicating noticeable differences in head shape.

Eye diameter (o/c) was 5.20 ± 0.05%, snout length (ao/c) was 5.70 ± 0.09%, and the coefficients of variation for these traits were around 5–7%. This shows that eye and snout dimensions are relatively stable (Table 2).

Table 2

Morphometric characteristics of rudd (Scardinius erythrophthalmus) from Ullishoʻrkoʻl lake (n=25)

Indicators	***Lim.***	***M±m***	***Σ***	***S²***	***Cv %***
l, mm	168,00-222,00	196,04±2,97	14,85	220,54	7,58
As a percentage of body length (*l*)					
c	20,41–23,60	21,79 ± 0,16	0,78	0,62	3,60
ao	4,73–6,59	5,70 ± 0,09	0,43	0,18	7,49
o	4,73–5,67	5,20 ± 0,05	0,26	0,07	5,04
po	10,19–12,42	10,89 ± 0,11	0,53	0,28	4,89
hc	10,18–19,11	16,30 ± 0,32	1,59	2,53	9,75
io	7,64–9,22	8,39 ± 0,09	0,44	0,19	5,20
H	28,68–35,23	31,89 ± 0,30	1,51	2,28	4,73
h	9,44–11,36	10,44 ± 0,10	0,51	0,26	4,86
aD	49,09–56,25	52,73 ± 0,27	1,37	1,87	2,59
pD	30,99–38,25	34,41 ± 0,30	1,49	2,21	4,32
Pl	12,10–16,27	14,37 ± 0,20	1,02	1,04	7,10
lD	14,19–18,31	15,55 ± 0,17	0,85	0,72	5,45
hD	16,99–23,94	19,87 ± 0,35	1,77	3,12	8,89
lA	10,53–13,50	12,29 ± 0,17	0,87	0,76	7,08
hA	11,46–14,77	12,74 ± 0,17	0,85	0,72	6,68
lP	13,07–17,20	15,41 ± 0,21	1,06	1,13	6,91
lV	13,07–17,20	15,51 ± 0,20	0,99	0,97	6,36
P–V	23,33–26,53	24,65 ± 0,17	0,84	0,70	3,39
V–A	23,35–25,85	24,46 ± 0,14	0,71	0,51	2,91
As a percentage of head length (*c*)					
ao/c	22,58–29,73	26,14 ± 0,31	1,54	2,39	5,91
o/c	21,62–26,67	23,88 ± 0,27	1,35	1,83	5,67
po/c	48,39–52,63	49,98 ± 0,24	1,22	1,49	2,45
hc/c	45,95–85,71	74,86 ± 1,44	7,20	51,83	9,62
io/c	35,00–42,11	38,52 ± 0,41	2,03	4,11	5,27

Continuation and completion of the translation:

The obtained morphometric indices show that body proportions in the population are generally stable, while certain traits exhibit noticeable phenotypic variability. Traits such as maximum body depth (H) and minimum body depth (h) stand out with relatively high values, indicating that the species is well adapted to active movement in the upper water layers, rapid changes in direction, and stable swimming. The variation in fin-related indices (lD, hD, lA, hA) is moderate, meaning that the fins form a relatively uniform morphological complex within the population.

The relatively small proportions of snout length (ao), eye diameter (o), and interorbital distance (io) relative to body length reflect the species' adaptation to feeding on natural food objects—soft aquatic vegetation, detritus, phytoplankton, and small zooplankton organisms. The low coefficients of variation for these traits indicate that feeding-related adaptations are consistently formed in the population.

Among the indices calculated relative to head length, the greatest variability is observed in head depth (hc/c) (Cv ≈ 9.6%), suggesting that head morphology is significantly influenced by external factors, age stages, or individual nutritional condition. Such plasticity in the head segment is evidence of the population's high adaptability to local ecological conditions.

The final analysis shows that although the basic skeletal-muscular complex of the body structure is stable in the population, phenotypic variation in head proportions remains quite pronounced. This morphometric structure confirms the species' ecological plasticity and its ability to optimally maintain efficiency of movement and feeding under the conditions of the given water body.

Conclusion

The Scardinius erythrophthalmus population from Ullishoʻrkoʻl Lake exhibits moderate variation in morphometric characteristics. The average body length is 196.04 ± 2.97 mm, and the stability of body proportions (Cv = 3–9%) indicates relative morphological homogeneity of the population. At the same time, the higher variation observed in head depth (Cv = 9.75%) is evidence of existing morphological diversity within the population. The elongated body shape and well-developed fins of the fish are important adaptive traits that ensure their ability to move effectively in water and maintain balance.

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EARTH SCIENCES

A GEOSPATİAL ANALYSİS OF CLİMATE CHANGE–İNDUCED TRANSFORMATİONS İN WATER BODİES

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Abstract

With the advancement of remote sensing technologies, satellite imagery has become a powerful tool for monitoring temporal and spatial variations in water bodies. This approach allows for precise observation of changes in lakes, rivers, reservoirs, wetlands, glaciers, snow cover, and groundwater systems. By leveraging satellite data, researchers can not only quantify fluctuations in water extents but also anticipate potential hydrological risks and design adaptive management strategies. Comparative analyses over time enable the detection of trends and patterns, providing crucial information for sustainable water resource planning and climate change impact assessment.

Keywords: GIS, mountain lakes, water resources, spatial-temporal dynamics

GIS-Based Analysis of Water Resources:

1. **Optical remote sensing** (e.g., Landsat, Sentinel-2) provides high-resolution imagery essential for tracking surface water dynamics.
2. **Radar satellites** (e.g., Sentinel-1) ensure continuous monitoring of water bodies even under cloud cover or adverse weather conditions.
3. **GRACE and GRACE-FO missions** allow for monitoring variations in groundwater storage and large-scale hydrological changes.
4. Data collected from these platforms are processed and analyzed using GIS software such as QGIS and ArcGIS, enabling visualization, mapping, and quantitative assessment of water body changes. An increase in the average temperature of water resources is observed. Of course, this situation leads to changes in the area of water resources. Lakes, which are an important component of land units, constitute up to 1% of the water resources of the hydrosphere. Despite having a very small percentage, these freshwater resources play an important role in the sustainable existence of the living environment in the ecosystem. Baku hosted an important event such as COP29 to solve such negative effects caused by climate change and examined ways to solve it.

What processes are monitored?	
I.	The effects of climate change on the spatial distribution of water resources are determined
II.	The impact on the reduction of water in reservoirs is assessed.
III.	Irrigation needs in agricultural areas are investigated and solutions are planned.
IV.	By identifying water scarcity problems, flood risks can be predicted in advance.

The emergence of sharp differences in water masses brings steps to be taken in this direction to the fore. The continuous increase in negative impacts leads to the activity and dynamism of this process. Remote Sensing has played a key role in investigating, studying and finding solutions to such global problems. This method obtains comprehensive information about the area without forcing observation on the ground, without physically observing the area. Remote sensing is used in a number of fields (military, humanitarian, geographical research).

In addition, research was conducted on 30 mountain lakes covering an area of 2 ha in the territories of Kalbajar, Lachin and Agdere. The total area of mountain lakes in that area is 900 ha. The largest lakes, covering 72% of the area, are Boyuk Alagol (Kalbajar), Ishikli Karagol (Lachin), Kichik Alagol (Kalbajar). Boyuk Alagol is located in the territory of the Karabakh volcanic plateau, in the Kalbajar region - 40°00′ N. E. 45°44′ N. W. geographical coordinates. The height of the lake is 2729 m above sea level. The maximum length is 3.7 km, and the widest is more than 9 m. Its volume is 24.3 million m³. The area of the lake is 5.1 km², and its length is 3670 m. The widest part is 2875 m, the average width is 1365 m, and the maximum depth is 9.4 m. There are also about 30 small lakes in this area, the largest of which is Kichik Alagöl after Boyuk Alagöl. Most of them dry up in the summer. The largest river is the Gurbagalı River, and 7 rivers flow into the lake. Kichik Alagöl is located at the geographical coordinates of 39°59′11″ N. E. 45°44′01″ N. W. The area of the lake is 0.9 km², and its length is 2000 m. The widest part is 825 m, and the length of the coastline is 5260 m. The deepest place is 4 m. Let's compare

the difference in change for the first 4 months of 2020 and 2024. The area of the lake decreased by 63.2 ha between January 2020 (465.4 ha) and January 2024 (402.2 ha). A decrease of 41.4 ha was observed in February, 31.9 ha in March, and 84.8 ha in April. Let's look at the illustration below.

Work progress

First, the research area is determined. Satellite data is obtained. The obtained data about water bodies is transmitted. Statistical classification of the data is carried out according to time. Finally, all the obtained data is analyzed and the results are transferred to maps. It is this specificity in the research that helps to obtain more accurate information. For this reason, the demand for the use of GIS has been increasing in recent years. At this time, it is possible to demonstrate the effectiveness of digital technologies by analyzing changes in water surfaces over a certain period of time based on satellite images. According to these analyses, the water bodies with the most spatial changes observed in Azerbaijan are as follows:

Water Basin Main changes and causes

Coasts of the Caspian Sea	Narrowing/widening of the coastline; erosion; water level changes
Kura and Araz rivers	Decrease in flow, anthropogenic infrastructure, water losses
Mountain lakes (Boyuk Alagöl)	Area changes as a result of climate change and melting pressure
Lake Aggol	Archaicization of the water regime, use of anthropogenic water masses

Table 1. Changes in Water Bodies Monitored Using GIS and Satellite Data (2023–2025)

Water Body Type	Region / Location	Area in 2023 (km²)	Area in 2024 (km²)	Area in 2025 (km²)	Trend	Main Influencing Factors
Mountain Lake	Caucasus Mountains	1.20	1.18	1.15	Decreasing	Glacial retreat, temperature rise
Reservoir	Mingachevir, Azerbaijan	590.0	585.0	580.0	Decreasing	Agricultural use, reduced rainfall
River Surface Area	Kura River	218.0	215.5	213.0	Slight decrease	Drought, irrigation demands
Wetland	Hajigabul Wetlands	36.0	37.5	39.0	Increasing	Seasonal precipitation, runoff increase
Glacier-fed Lake	Shahdag Region	0.82	0.80	0.78	Decreasing	Glacier melting, climate warming
Groundwater Storage	Central Azerbaijan	-2.0 Gt	-3.5 Gt	-4.8 Gt	Decreasing	Over-extraction, climate variability

Water resources are vital components of the global ecosystem, supporting biodiversity, human activities, and climate regulation. However, these resources are increasingly threatened by climate change and anthropogenic activities, such as intensive agriculture, urban expansion, and water extraction. Monitoring temporal and spatial changes in water bodies is therefore essential for sustainable water management and environmental protection.

Recent advances in remote sensing and Geographic Information Systems (GIS) provide an effective framework for assessing these changes. Optical satellites, such as Landsat and Sentinel-2, allow high-resolution observation of surface water bodies, while radar satellites like Sentinel-1 enable monitoring under cloudy or adverse weather conditions. Furthermore, GRACE and GRACE-FO satellites provide insights into groundwater variations, which are not directly observable from surface imagery.

This study focuses on the analysis of water body dynamics in Azerbaijan from 2023 to 2025. Selected water bodies include mountain lakes, reservoirs, rivers, wetlands, glacier-fed lakes, and groundwater storage areas. By using GIS-based spatial and temporal analysis, the study identifies trends in surface area and storage, evaluates the impacts of climate change, and highlights the main factors influencing these changes. The results aim to inform water resource management, support decision-making, and provide guidance for mitigating potential ecological and socio-economic risks associated with water scarcity or overuse.

Preliminary GIS analysis reveals significant spatial variations in water bodies over the studied period. Reservoirs and rivers show measurable reductions in surface area in some regions, while mountain lakes and wetlands exhibit seasonal fluctuations influenced by both climatic and anthropogenic factors. Groundwater storage patterns, inferred from GRACE data, highlight areas at risk of depletion. These results underscore the importance of integrating satellite and GIS technologies for comprehensive water resource monitoring. Geospatial technologies provide a robust framework for assessing climate change-induced transformations in water bodies. By combining satellite data and GIS analysis, it is possible to monitor trends, identify vulnerable areas, and support informed decision-making for sus-

tainable water management. Future research should focus on integrating climate models with geospatial analysis to improve predictive capabilities and enhance water resource resilience.

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MODERN SCIENTIFIC THEORETICAL CONCEPTIONS OF THE INVESTIGATIONS OF THE PROBLEMS OF LAND USE IN UKRAINE

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СУЧАСНІ НАУКОВІ ТЕОРЕТИЧНІ КОНЦЕПЦІЇ ДОСЛІДЖЕНЬ ПРОБЛЕМ ЗЕМЛЕКОРИСТУВАННЯ В УКРАЇНІ

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Abstract
Investigations of the land use problems are interdisciplinary. Their decision predicts using data from the fields of physical and constructive geography, ecology, agricultural science, geodesy, economy, law. The key role in these investigations believes to the system approach. The conceptions of sustainable development, noosphere and noospheric ecosystems have an important significance. The main principles of the investigations of the land use problems are principles of complexity, determinism and general connections and interaction.

Анотація
Дослідження проблем землекористування є міждисциплінарними. Їх вирішення передбачає використання даних фізичної та конструктивної географії, екології, аграрної науки, геодезії, економіки, права. Ключова роль у цих дослідженнях належить системному підходові. Важливе значення мають концепції сталого розвитку, ноосфери і ноосферних екосистем. Головними принципами досліджень проблем землекористування є принципи комплексності, детермінізму, загального зв'язку та взаємодії.

Keywords: land use, system approach, conception of sustainable development, noosphere, principle.
Ключові слова: землекористування, системний підхід, концепція сталого розвитку, ноосфера, принцип.

Важливою рисою сучасного землекористування в Україні є істотна деградація земельних ресурсів, зумовлена збідненням ґрунтів внаслідок нераціональної сільськогосподарської діяльності, посилення екологічних наслідків промислового виробництва та диспропорційною структурою земельних угідь.

Особливістю методологічних засад досліджень земельних ресурсів і землекористування є те, що, на відміну від інших видів природних ресурсів, вони мають певні виняткові властивості. Зокрема, земельні ресурси характеризуються територіальною обмеженістю, не підлягають переміщенню у просторі та не можуть бути замінені іншими засобами виробництва. Крім того, земельні ресурси пов'язані з природними умовами, які визначають їхню якість. Водночас за умови раціонального використання земельних ресурсів їх можна не лише зберегти, а й, хоча б частково, поліпшити їхні характеристики. Зокрема, це має стати можливим завдяки застосуванню конструктивістського підходу до формування структури землекористування.

Дослідження проблем землекористування, в силу самої їхньої сутності, перебувають на межі кількох наук – аграрної науки, геодезії, екології, еко-

номіки, права і, далеко не в останню чергу, географії. Адже будь-яка ділянка земної поверхні приурочена до конкретного фрагменту геопростору, характеризованого певними природними умовами. Цими умовами великою мірою й визначається місце території у структурі земельних ресурсів, її оцінка з погляду ймовірної врожайності сільськогосподарських культур. Тому питання землекористування значною мірою належить до компетенції географічних наук, а саме – географії ґрунтів, геоморфології, кліматології, економічної географії тощо, інтегруючу роль щодо яких відіграє сучасна конструктивна географія.

Структура землекористування, на нашу думку, залежить від кількох чинників, а саме – щонайменше – від природного, історичного, економічного та екологічного. Перші два визначають структуру землекористування на початку її формування, економічний та екологічний виступають як визначальні вже у подальшому реформуванні, й сьогодні вони є пріоритетними.

Серед методологічних засад досліджень проблем землекористування провідні місця посідають системний і синергетичний підходи, фундаментальні положення сучасної конструктивної географії та екології, а також концепції сталого розвитку, ноосфери і ноосферних екосистем.

Системний підхід є стрижневою засадою досліджень проблем землекористування. Як зазначають С. А. Мороз, В. І. Онопрієнко й С. Ю. Бортник, системний підхід – це поняття, що «в цілому відбиває стратегічне намагання надати дослідженням всеосяжний характер, пов'язати в систему відкриті та ті, що заново відкриваються, факти і закономірності, подати знання у вигляді деякої логічно несуперечливої єдиної системи або схеми» [2, p. 118]. Ще наприкінці XIX – в першій половині XX ст. розроблено низку географічних концепцій, що мали виразно системний характер – зокрема, ландшафтну (J. Wimmer [9]), хорологічну (A. Hettner [7]), біосферну (В. І. Вернадський [6], ноосферну (P. Teilhard de Chardin [8]) та ін.). У другій половині минулого сторіччя напрацьовано концепцію сталого розвитку, що дала змогу вдосконалити системологічні дослідження в географії. Як зауважував О. Г. Топчієв, «найважливішим завданням сучасного розвитку географічної науки є конкретизація системної концепції в кожному з напрямків географічних досліджень, в кожній окремій методиці» [5].

Безпосередньо в аспекті питань землекористування можливість застосування системного підходу аналізували І. М. Андріішин та А. Я. Сохнич [1].

Яскравим прикладом застосування системного підходу в дослідженні обраної нами проблеми може бути аналіз структури й динаміки земельних угідь. Ці угіддя, що складаються з пасовищ, сіножатей, ріллі, а остання, у свою чергу, з різних сівозмін, являють собою складний об'єкт (отже, його можна розглядати як систему) із характерними для нього властивостями (ієрархічністю будови, емерджентністю тощо).

Системний підхід у дослідженнях проблем землекористування проявляється й при аналізі співвідношення просторових і часових закономірностей формування сучасної структури земельних ресурсів.

Важливою складовою методологічної основи досліджень проблем землекористування є концепції сучасної екології. Також вагомою частиною методологічної основи нашого дослідження є теорія генетичного ґрунтознавства, розроблена у другій половині XIX ст. Н. Д. Борисяком і В. В. Докучаєвим. Саме ґрунт визначає можливості використання земель у сільськогосподарському виробництві. Відповідно, території, зайняті найбільш родючими ґрунтами, за жодних умов недопустимо виводити з категорії земель сільськогосподарського призначення. Навпаки, ділянки з менш родючими ґрунтами доцільно використовувати для несільськогосподарських потреб (промислове виробництво, будівництво, прокладання шляхів сполучення тощо).

Відповідно до положень учення В. В. Докучаєва, дія чинників ґрунтоутворення є рівноцінною. Тому й структура посівних площ (як і сама можливість ведення землеробської діяльності) залежить від цих чинників.

Поряд із методологічними підходами, що традиційно використовуються фізичною та конструктивною географією (описовим, геокомпонентним, геокомплексним, геосистемним, ландшафтним тощо), в останні десятиріччя стали застосовуватися якісно нові, яким, на відміну від класичних і некласичних підходів, не властивий антагонізм у взаєминах суб'єкта й об'єкта дослідження. Більше того, спостерігається суб'єкт-об'єктна збіжність (взаємний перехід суб'єкта в об'єкт і навпаки, їх позиціонування як певної цілості). Прикладами таких підходів є екоеволюційний (більш відомий як концепція сталого розвитку, прийнята багатьма державами світу на міжнародній конференції з екологічної проблематики в Ріо-де-Жанейро в 1992 р.; термін «екоеволюційність» належить В. М. Пащенку [3], який уважає його найбільш точним і коректним) та ноосферний, що являє собою географічну інтерпретацію загальнонаукового й філософського вчення про ноосферу, розробленого незалежно одне від одного П. Тейяр де Шарденом [8] і В. І. Вернадським [6]. На нашу думку, зазначені новітні (некласичні та постнекласичні) підходи в географічних дослідженнях повною мірою можуть використовуватися при розгляді проблем землекористування.

На основі вчення В. І. Вернадського про ноосферу сучасний український географ С. П. Сонько сформулював концепцію ноосферних екосистем [4].

До принципів дослідження проблем землекористування ми відносимо принципи комплексності, детермінізму (наявності провідного чинника), загального зв'язку та взаємодії тощо.

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ECONOMIC SCIENCES

A SYSTEMIC APPROACH TO BUILDING INNOVATIVE INFRASTRUCTURE IN THE AGRARIAN PRODUCTION COMPLEX

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Abstract
The sustainable development of the agrarian production complex requires the purposeful and well-coordinated establishment of innovative infrastructure. A systemic approach creates the conditions for forming an integrated structure, ensuring optimal allocation of resources, and strengthening the interconnections within the production chain. This approach transforms traditional agricultural production into a more flexible, digital, and technologically advanced system.

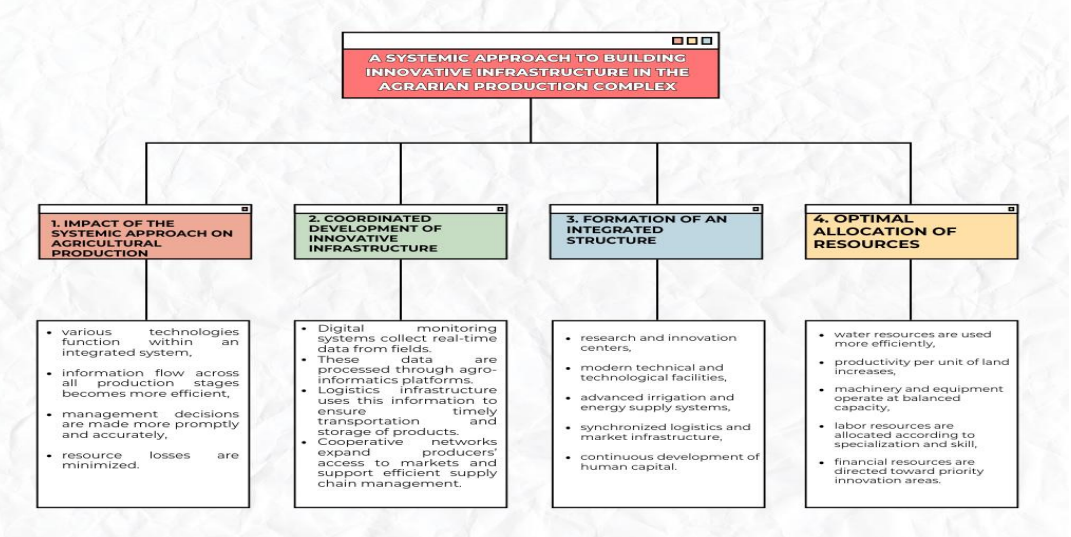
Keywords: Agrarian production complex, Innovative infrastructure, Systemic approach, Sustainable development, Technological innovation

The sustainable development of the agrarian production complex requires the purposeful and well-coordinated establishment of innovative infrastructure. A systemic approach creates the conditions for forming an integrated structure, ensuring optimal allocation of resources, and strengthening the interconnections within the production chain. This approach transforms traditional agricultural production into a more flexible, digital, and technologically advanced system.

Implementing a systemic approach to develop innovative infrastructure in the agrarian production complex is essential for ensuring efficient use of resources and coordinated growth. This approach combines modern technologies, data-driven decision-making, and interconnected production processes to enhance productivity while minimizing operational risks. Incorporating innovation allows the adoption of new management practices and equipment, enabling the sector to adapt to changing market demands and environmental conditions. Overall, a structured and innovative framework is key to modernizing agriculture and supporting sustainable development.

Applying a systemic approach to develop innovative infrastructure in Azerbaijan's agrarian production complex is crucial for optimizing resource use and promoting coordinated growth. By integrating modern technologies, data-driven decision-making, and connected production processes, the approach enhances productivity and reduces operational risks in the agricultural sector. Innovation supports the introduction of new management practices and equipment, helping Azerbaijani agriculture adapt to evolving market demands and environmental challenges. Overall, a structured and innovative framework is essential for modernizing Azerbaijan's agriculture and achieving sustainable development.

Scheme 1. A Systemic Approach to Developing Innovative Infrastructure in Agrarian Production: Key Components and Impacts


A SYSTEMIC APPROACH TO BUILDING INNOVATIVE INFRASTRUCTURE IN THE AGRARIAN PRODUCTION COMPLEX
1. IMPACT OF THE SYSTEMIC APPROACH ON AGRICULTURAL PRODUCTION
various technologies function within an integrated system,
information flow across all production stages becomes more efficient,
management decisions are made more promptly and accurately,
resource losses are minimized.
2. COORDINATED DEVELOPMENT OF INNOVATIVE INFRASTRUCTURE
Digital monitoring systems collect real-time data from fields.
These data are processed through agro-informatics platforms.
Logistics infrastructure uses this information to ensure timely transportation and storage of products.
Cooperative networks expand producers' access to markets and support efficient supply chain management.
3. FORMATION OF AN INTEGRATED STRUCTURE
research and innovation centers,
modern technical and technological facilities,
advanced irrigation and energy supply systems,
synchronized logistics and market infrastructure,
continuous development of human capital.
4. OPTIMAL ALLOCATION OF RESOURCES
water resources are used more efficiently,
productivity per unit of land increases,
machinery and equipment operate at balanced capacity.
labor resources are allocated according to specialization and skill,
financial resources are directed toward priority innovation areas.

1. Impact of the Systemic Approach on Agricultural Production

The systemic approach in agriculture addresses fragmented management and isolated infrastructure issues by integrating all components into a unified mechanism. This integration leads to several key benefits:

- Integrated technologies: Various agricultural technologies operate within a coordinated system rather than independently, ensuring smoother and more efficient operations.
- Efficient information flow: Data is shared effectively across all production stages, enabling timely monitoring of soil conditions, crop status, and environmental factors.
- Improved decision-making: Managers can make decisions more quickly and accurately due to the availability of complete and reliable information.
- Minimized resource losses: Coordinated operation of all system components reduces waste of water, fertilizers, energy, and time.

Overall, this holistic perspective enhances both the efficiency and stability of agricultural processes, increasing productivity while reducing risks.

2. Coordinated development of innovative infrastructure

Building innovative infrastructure is not limited to introducing new technologies; it also requires establishing strong linkages among them. For example:

- Digital monitoring systems collect real-time data from fields.
- These data are processed through agro-informatics platforms.
- Logistics infrastructure uses this information to ensure timely transportation and storage of products.
- Cooperative networks expand producers' access to markets and support efficient supply chain management.

Such coordination enhances efficiency at every stage of production and strengthens the overall innovation environment.

3. Formation of an integrated structure

An integrated structure refers to the harmonious interaction of all components of the agrarian production system. This includes:

- **research and innovation centers**,
- **modern technical and technological facilities**,
- **advanced irrigation and energy supply systems**,
- **synchronized logistics and market infrastructure**,
- **continuous development of human capital**.

When these components complement one another, the agricultural sector becomes more dynamic, competitive, and innovation-driven.

4. Optimal allocation of resources

Within a systemic approach, resources such as land, water, labor, finance, and technology are not managed separately; instead, they are optimized based on the overall needs of the system. This ensures that:

- water resources are used more efficiently,
- productivity per unit of land increases,
- machinery and equipment operate at balanced capacity,
- labor resources are allocated according to specialization and skill,
- financial resources are directed toward priority innovation areas.

The result is higher productivity with reduced waste and lower production risks.

5. Strengthening interconnections within the production chain

Strengthening linkages among all participants in the agricultural value chain — farmers, cooperatives, service providers, processing enterprises, and market actors — is essential for improving competitiveness. Innovative infrastructure supports these interactions through:

- digital platforms for data exchange and planning,
- electronic commerce and market access tools,
- cooperative-based collaboration networks,
- unified production and quality standards,
- automated information management systems.

These improved connections enhance continuity, transparency, and resilience throughout the entire agrarian production system.

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DIGITALIZATION AND ITS ROLE IN ECONOMIC DEVELOPMENT

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DOI: 10.5281/zenodo.18003322

Abstract

Digitalization has become one of the core drivers of global economic transformation. This article examines the impact of digital technologies on Azerbaijan's economic development, focusing on public administration, business competitiveness, human capital, and diversification of the non-oil sector. The study highlights the significance of digital reforms implemented in the country and assesses their contribution to sustainable socio-economic growth. [2]

Keywords: digitalization, economic development, Azerbaijan, innovation, e-government

Introduction

In the 21st century, digitalization has become one of the main driving forces of the global economy. The rapid development of information and communication technologies (ICT) has fundamentally transformed economic, social, and administrative systems worldwide. Countries that remain outside this process risk losing their competitiveness. Azerbaijan considers digital transformation one of its strategic development priorities. In recent years, the expansion of digital infrastructure, the development of e-government services, the formation of an innovation ecosystem, and the implementation of digital solutions across various economic sectors have significantly accelerated.[1,3]

This article analyzes the main directions of digitalization in Azerbaijan, its contributions to economic and social development, and the strategic importance of the country's digital transformation.

1. Stages of Digitalization in Azerbaijan

1.1. Initial Stage: Formation of ICT Infrastructure

Since the early 2000s, Azerbaijan has declared the creation of an information society a national priority. During this period, the focus was directed toward: [4]

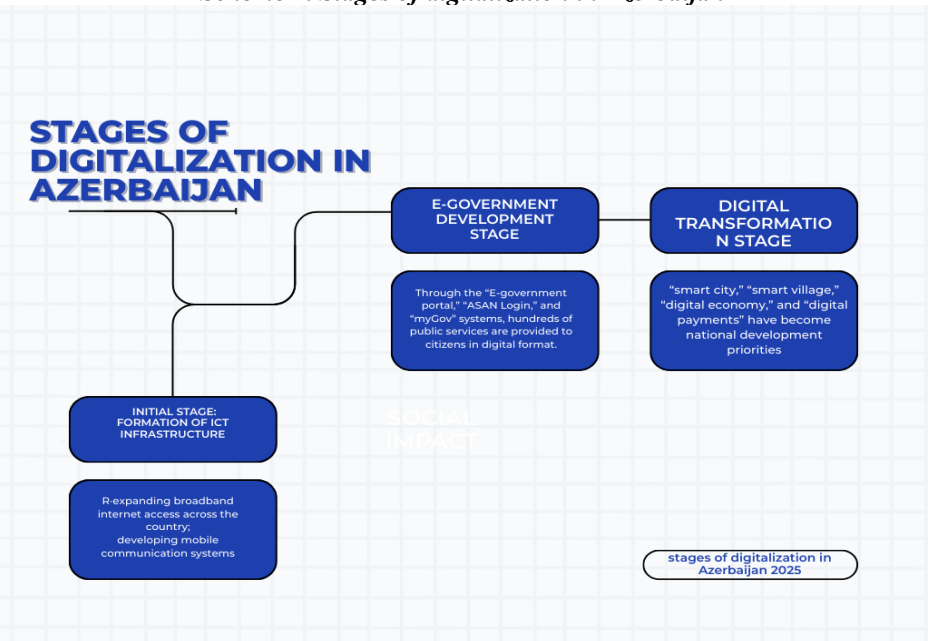
- expanding broadband internet access across the country;
- developing mobile communication systems;
- increasing the use of ICT in state institutions;
- implementing international standards in information security.

The adoption of the "Electronic Azerbaijan" State Program in 2003 laid the foundation for digital transformation. [5]

1.2. E-Government Development Stage

From the 2010s, the digitalization of public administration became a major priority. The "ASAN Service" model is among the most successful examples of this process. Through the "E-government portal," "ASAN Login," and "myGov" systems, hundreds of public services are provided to citizens in digital format.

Scheme 2. Stages of digitalization in Azerbaijan


STAGES OF DIGITALIZATION IN AZERBAIJAN
E-GOVERNMENT DEVELOPMENT STAGE
DIGITAL TRANSFORMATIO N STAGE
Through the "E-government portal," "ASAN Login," and "myGov" systems, hundreds of public services are provided to citizens in digital format.
"smart city," "smart village," "digital economy," and "digital payments" have become national development priorities
INITIAL STAGE: FORMATION OF ICT INFRASTRUCTURE
R-expanding broadband internet access across the country; developing mobile communication systems
SOCIAL IMPACT
stages of digitalization in Azerbaijan 2025

1.3. Digital Transformation Stage

Since 2020, concepts such as "smart city," "smart village," "digital economy," and "digital payments" have become national development priorities. The preparation of the Artificial Intelligence Strategy, the establishment of innovation centers, and the expansion of the startup ecosystem indicate the transition to a more advanced stage of digital transformation.

2. The Role of Digitalization in Economic Development

2.1. Increasing Efficiency in Production and Services

Digitalization leads to higher labor productivity and lower production costs. Modern ERP systems, automated production lines, digital logistics, and smart management platforms enable companies to operate more efficiently.

2.2. Formation of New Economic Sectors

The digital economy fosters not only the development of existing sectors but also the creation of entirely new markets. In Azerbaijan, the following areas are expanding rapidly:

Increased Transparency and State Revenue

Digital payments, e-invoices, and electronic accounting systems reduce the shadow economy. The digitalization of tax and customs processes increases state budget revenues and minimizes corruption risks. [3]

2.4. Digitalization of the Agricultural Sector

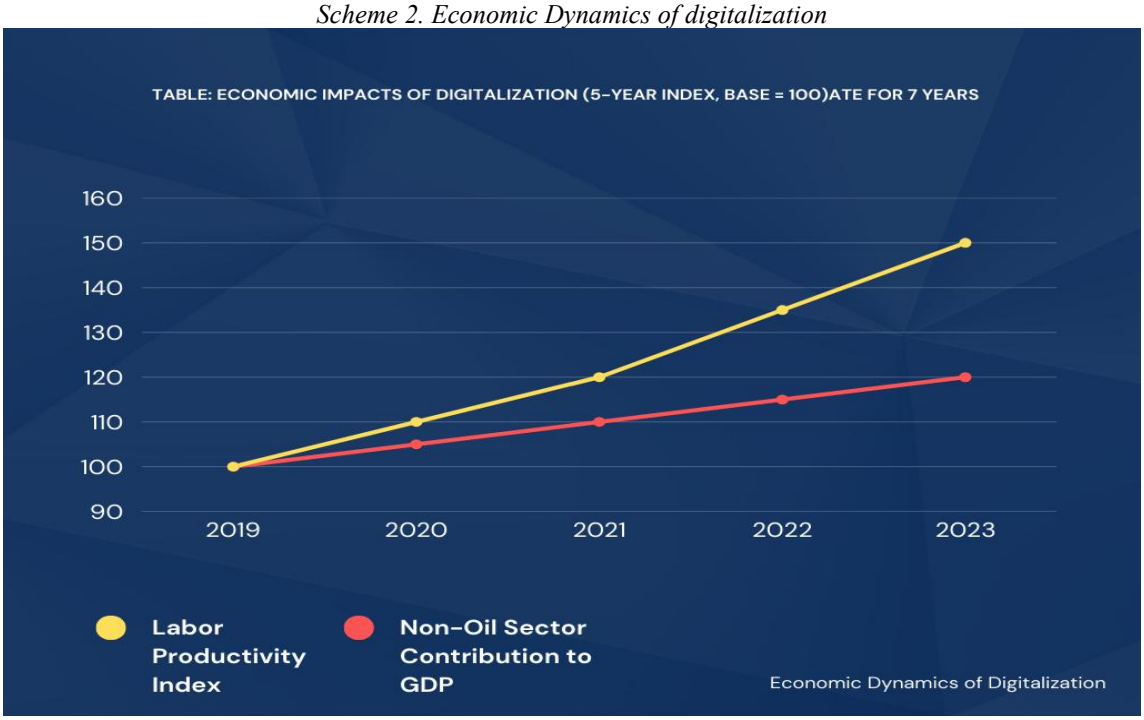
The "Agricultural Information System," drone monitoring, GPS-controlled machinery, and digital irrigation systems increase productivity and reduce resource waste in agriculture. [4,5]

3. Digitalization in Public Administration ; 3.1. The ASAN Service Model

ASAN Service is an internationally recognized example of digital governance. Its advantages include: [2,3]

- speed and transparency;
- reduction of corruption risks;
- fully digitalized service delivery;
- increased citizen satisfaction.
-

Scheme 2. Economic Dynamics of digitalization



3.2. E-government Platforms

Through these systems, citizens can access:

- electronic certificates;
- social insurance information;
- tax declarations;
- property registration services;
- digital banking and legal documentation.

3.3. Strengthening Digital Communication

Digital communication channels allow faster interaction between the state and citizens. Online applications, electronic queue systems, and e-receipts enhance public administration efficiency.

5. Strategic Importance of Digital Transformation in Azerbaijan

5.1. Enhancing Competitiveness

Digitalization strengthens Azerbaijan's position in the global economy. Innovative technologies create a more attractive business environment and stimulate foreign investment.

5.2. Regional Leadership Potential

Azerbaijan is one of the leading countries in the South Caucasus in terms of digital transformation. Cross-border fiber-optic projects, data centers, and regional digital corridors strengthen the country's strategic role.

5.3. Contribution to Sustainable Development Goals

Digital technologies accelerate the implementation of the UN Sustainable Development Goals by ensuring:

- efficient use of resources;
- reduction of carbon emissions;
- creation of an inclusive society.

5.4. Ensuring Economic Diversification

The digital economy plays a vital role in reducing dependence on oil resources and strengthening the non-oil sector.

Conclusion

Digitalization in Azerbaijan is an integral part of large-scale structural reforms. Digital transformation enhances economic efficiency, modernizes public administration, improves social service accessibility, and accelerates innovative development. It strengthens the country's competitive advantages and supports sustainable growth. Considering the existing potential and ongoing initiatives, Azerbaijan is expected to become one of the leading digital hubs of the region in the near future.

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THE IMPACT OF DIJIMODERN CONSUMER BEHAVIOR ON CONTEMPORARY MARKET MODELS

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Abstract

This paper examines the impact of dijimodern consumer behavior on contemporary market models. The dijimodern era is defined by rapid technological advancement, widespread digital connectivity, and the growing influence of social media on consumer decision-making. Consumers in this environment demonstrate unique characteristics such as high digital literacy, preference for personalized experiences, and rapid shifts in brand loyalty. This paper analyzes how these behavioral patterns influence market structures, marketing strategies, and business models, and emphasizes the importance of data-driven decision-making in contemporary markets.

Keywords: Dijimodern consumer behavior, digital literacy, personalization, social influence, market models, consumer trends, digital economy

Introduction

Technological innovation has fundamentally reshaped consumer behavior in the twenty-first century. The term "dijimodern" refers to consumers who are deeply integrated into digital ecosystems, relying on online platforms for information, social interaction, and purchasing decisions. Unlike traditional consumers, dijimodern consumers are highly informed, socially connected, and sensitive to ethical, environmental, and social factors in their consumption.

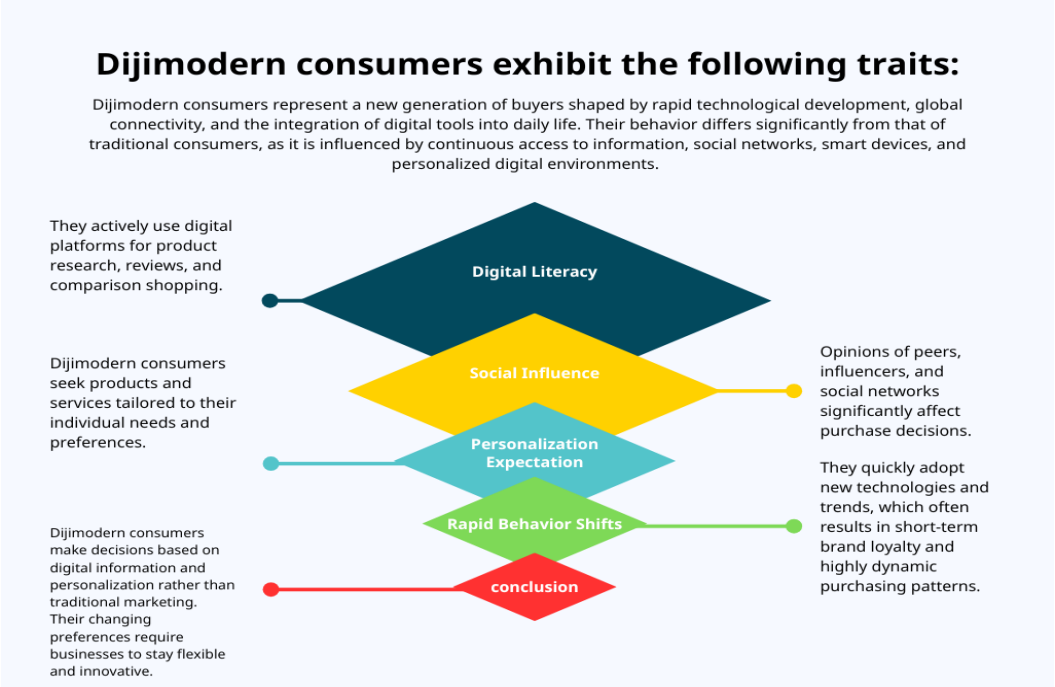
The shift toward dijimodern consumption has challenged traditional market models, necessitating the development of more dynamic, flexible, and interactive strategies. Businesses must understand these consumers' preferences, anticipate their behavior, and leverage digital tools to maintain competitive advantage.

Impact on Contemporary Market Models

The influence of dijimodern consumer behavior has transformed several key aspects of contemporary market models:

- **Omnichannel Integration**: Businesses must synchronize online and offline channels to provide a seamless customer experience. Physical stores, mobile apps, and e-commerce platforms now operate as integrated components of a single market strategy.
- **Customer Engagement**: Companies are now required to engage consumers beyond the transactional level. Brand interactions involve social responsibility, personalized communication, and ethical practices.
- **Data-Driven Marketing**: Market models increasingly rely on analytics to predict consumer behavior. Big data enables targeted campaigns, dynamic pricing, and precise segmentation.
- **Innovation and Flexibility**: Traditional linear marketing models are being replaced by adaptive models that can respond to rapidly changing consumer expectations and digital trends.
-

Scheme1. Characteristics of Dijimodern Consumers
Dijimodern consumers exhibit the following traits:


Dijimodern consumers exhibit the following traits:
Dijimodern consumers represent a new generation of buyers shaped by rapid technological development, global connectivity, and the integration of digital tools into daily life. Their behavior differs significantly from that of traditional consumers, as it is influenced by continuous access to information, social networks, smart devices, and personalized digital environments.
They actively use digital platforms for product research, reviews, and comparison shopping.
Digital Literacy
Dijimodern consumers seek products and services tailored to their individual needs and preferences.
Social Influence
Opinions of peers, influencers, and social networks significantly affect purchase decisions.
Personalization Expectation
They quickly adopt new technologies and trends, which often results in short-term brand loyalty and highly dynamic purchasing patterns.
Rapid Behavior Shifts
Dijimodern consumers make decisions based on digital information and personalization rather than traditional marketing. Their changing preferences require businesses to stay flexible and innovative.
conclusion

Implications for Market Strategy

Organizations must adopt strategies that reflect the behavior of dijimodern consumers:

- **Personalized Marketing**: Tailoring offers and communications to individual preferences enhances engagement and conversion.
- **Ethical and Social Responsibility**: Transparent practices and social contributions resonate with dijimodern consumers and strengthen brand perception.
- **Real-Time Analytics**: Leveraging data analytics for rapid response to market trends and consumer behavior improves decision-making efficiency.
- **Omnichannel Customer Experience**: Ensuring consistency across digital and physical touchpoints strengthens loyalty and brand identity.

Understanding dijimodern consumers allows businesses to develop adaptive, data-driven, and customer centric strategies that enhance engagement, loyalty, and competitiveness. As global markets continue to digitize and consumer expectations evolve, examining the characteristics and influence of dijimodern consumers becomes essential for companies striving to maintain relevance and achieve sustainable growth.

Scheme1. Adapting Strategies for Dijimodern Consumers

Dynamic Changes in the Impact of Dijimodern Consumer Behavior on Contemporary Market Models Over the Years

The influence of dijimodern consumer behavior on market models has evolved significantly over the past two decades, driven by technological advancements and changing social dynamics:

2000–2010: Emergence of Digital Consumers

During this period, the widespread adoption of the internet and early e-commerce platforms marked the emergence of digital consumers. Consumers began researching products online and comparing prices, but social media influence was still limited. Market models started integrating online sales channels alongside traditional ones.

2011–2015: Rise of Social Influence and Mobile Technology

With the growth of smartphones and social media platforms such as Facebook, Twitter, and Instagram, consumer behavior became increasingly shaped by peer opinions and influencer recommendations. Companies adapted by developing social media marketing strategies and mobile-friendly services to reach this more connected audience.

2016–2020: Personalization and Omnichannel Strategies

During this period, dijimodern consumers demanded personalized experiences. Brands responded with tailored marketing campaigns, recommendation algorithms, and integrated omnichannel strategies to ensure seamless experiences across physical and digital touchpoints.

2021–Present: Data-Driven and Socially Conscious Consumption

Currently, dijimodern consumers expect brands to be transparent, socially responsible, and environmentally conscious. Companies increasingly rely on big data analytics, AI, and real-time market insights to predict behavior and respond dynamically to trends. Brand loyalty has become more fluid, requiring continuous adaptation of market strategies.

The study of dijimodern consumer behavior and its impact on contemporary market models is highly relevant in today's rapidly evolving digital economy. The widespread adoption of digital technologies, social media, and mobile platforms has transformed how consumers access information, interact with brands, and make purchasing decisions. Traditional marketing strategies are increasingly insufficient to address the needs of this highly informed, socially connected, and personalization-seeking consumer segment.

Conclusion

Dijimodern consumer behavior is a transformative force in contemporary markets. Businesses that fail to adapt risk losing relevance in increasingly competitive digital environments. Successful adaptation requires understanding consumer digital habits, engaging them meaningfully, and using data-driven strategies to anticipate and respond to behavioral shifts. Contemporary market models must evolve continuously to accommodate the dynamic, personalized, and socially aware nature of dijimodern consumers.

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APPLICATIONS OF ARTIFICIAL INTELLIGENCE (AI) IN THE TEXTILE INDUSTRY

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Abstract
The purpose of this article is to applications of artificial intelligence (AI) in the textile industry. To achieve the scientific goal in this article are used descriptive-analytical method, study of various scientific literature about applications of artificial intelligence (AI) in the textile industry, systematic approach, comparative analysis, method of observation, induction, deduction, etc. In conclusion, it has been established that at the current stage of development of digital technologies and innovations, artificial intelligence (AI) is of increasing importance for the development of the textile industry. With the implementation, integration and development of artificial intelligence (AI), companies in the textile industry can optimize their processes, activities, textile products, quality control, thereby increasing the efficiency of their business organization.

Keywords: artificial intelligence, AI, textile, textile industry.

Introduction

The textile industry plays a key role in the economy, as the sector is based on the correct selection of quality textile raw materials, the composition of yarns, which in the weaving process form fabrics from different textile materials, and in the cutting process, textile products are formed, which are previously dyed. A huge variety of different types of textile products are produced using different technological schemes and processes, as well as complex finishing and dyeing procedures. To improve quality, increase production and reduce operating costs, internal control over production is exercised, which leads to shorter lead times, AI is used, which is quickly becoming a key tool for textile companies [1].

Before 1949, computers were not intelligent, as they could not write commands, but they could execute them. Between 1957 and 1974, artificial intelligence (AI) developed, increasing computer memory, speed, cost, and accessibility. AI enables machines to perform various tasks that humans must perform with their natural intelligence. In 1950, AI creators Marvin Minsky and John McCarthy defined artificial intelligence, which allows machines to achieve certain goals by analyzing vast amounts of unstructured data in the form of text, images, and audio. AI is relevant to almost every industry and will continue to grow strongly in the future. Machine learning and computer algorithms have been widely used in testing in the textile industry since the 1980s. Testing and quality control using AI can be defined through image processing, automation, training, and neural networks. The majority of the textile industry these days uses computer-aided machines in the production process, to create designs and access data to improve efficiency [2].

Artificial intelligence (AI) is being used in more and more industries, and the textile industry is no exception. The implementation and integration of artificial intelligence (AI) in the textile industry is transforming a number of activities related to conventional production, design and interaction with consumers of textile products. Through the use of AI, it becomes possible to increase efficiency, sustainability and innovation in the textile industry. The advantage of AI in the textile industry is the ability to process large amounts of data and, based on them, make decisions that optimize the production process and design of textile products. In addition, artificial intelligence in the textile industry is also useful in terms of defect detection, accuracy in predicting consumer demand, accuracy in supply chain management, waste minimization, optimization of resource use and sustainability in the textile industry [3].

Artificial intelligence (AI) is a powerful tool for increasing productivity in the textile industry, developing design concepts, predicting upcoming trends, detecting defects, assessing quality and evaluating the colors of textile products. AI enables the improvement of the quality of textile products, reduces labor costs, increases production speed, and its application is likely to increase in the future [4].

The textile industry has increasingly started to use artificial intelligence (AI) methods, as it can gain a lot from AI systems that can help optimize various processes in production, quality, statistical control, information, costs and output. AI develops and applies various models and analyzes huge volumes of quantitative data, allowing their optimal use [1]. The reason for research on the application of AI in the textile industry is its increasing penetration into companies.

The purpose of this article is to study to applications of artificial intelligence (AI) in the textile industry.

Methodology

To achieve the scientific goal in this article are used descriptive-analytical method, study of various scientific literature about applications of artificial intelligence (AI) in the textile industry, systematic approach, comparative analysis, method of observation, induction, deduction, etc..

Results and discussion

An important aspect of textile production is the quality control of manufactured textile products. Early identification of defects is essential for ensuring the

quality of textile products, which provides a competitive advantage to companies. Quality determination is carried out by inspecting textile products through visual and tactile inspection for defects, which creates challenges and opportunities for human error. This *enables artificial intelligence (AI) to be applied in the textile industry* through image processing, computer vision and machine learning to *detect defects with better speed*, accuracy and reliability compared to inspection by quality inspectors. The study presents the different types of defects in textile products that occur at different stages of production. In addition, the advantages and disadvantages of conventional and automated approaches are evaluated, emphasizing the key role of achieving high accuracy in identifying defects in textile products. The study also examines the integration of AI technologies, such as high-resolution cameras, real-time surveillance systems, in the quality control processes of textile products in the context of sustainability, optimization of production processes and the profitability of companies in the textile industry in the context of digital transformation [5].

Another study presents the *integration and implementation of a system (artificial intelligence (AI) and computer vision) for textile defect detection, tailored for the textile industry*. The detection of defects (holes, color bleeding and creases on plain-colored cotton and linen fabrics without patterns) is essential for ensuring the quality of textiles in textile production, as manual inspection is prone to errors, making it ineffective. When studying the quality of textiles, each detected defect is registered with a location, class, credibility assessment and a unique identifier, which are needed for further quality analysis. The analysis is performed by two cameras, which are located about 1 m from the textiles under controlled lighting conditions in a real industrial environment [6].

The study analyzed *the applications of artificial intelligence (AI) in the textile industry*, which include various techniques for textile yarn analysis, textile fabric inspection, improving the productivity of the production process, using neural networks and artificial vision. Regarding the *advantages* of using AI in the textile industry, it was found that all these techniques allow for better analysis of textile yarn and identification of defects in textile products. A *disadvantage* of the AI used in the textile industry is the fact that they do not have a standardized algorithm that can be used, which makes their application more difficult [7].

The textile industry in India is the second largest employment sector and the largest contributor to the country's GDP. The study found that the textile industry is lagging behind in terms of technological innovation. The introduction of AI in the textile industry will lead to increased efficiency by quickly bringing diverse ideas to market at lower levels of labor and costs in textile production, which will optimize the supply chain and increase consumer satisfaction. In addition, AI will help develop and maintain sustainability, which will help manufacturers and distributors adapt to market demand. The article concludes that the *implementation of AI in the textile industry has led to improved efficiency* of the production process in companies by automating design processes, increasing worker productivity and reducing the time to develop textile products [8].

The *application of AI in the textile industry through mechatronics* has existed for a long time, with its applications related to the design of textile machines (weaving and LAN weaving systems, 3D interlacing; yarn tension compensation; texturing; spinning: measurement automation and diagnostics, knowledge-based expert systems; automated garment production and assembly; and garment manufacturing). Mechatronic design in the textile industry contains the opportunity to optimize the concept of mechatronics and design methodology and the impact of technological advances on the concept of mechatronics, which has a multifaceted application in the textile industry and leads to process optimization in companies [9].

In today's environment, the majority of consumers prefer to wear textiles that are in line with the latest fashion trends. For this reason, textile companies need to meet the growing consumer demand for a variety of textile products, which should be achieved by increasing production capacity and improving operational efficiency through AI. *Companies are increasingly using AI* and its various tools to improve their processes and related activities. AI is beneficial to companies by establishing significant relationships with demand forecasting, decision making, and textile supply. The results of the study show that AI is highly correlated with all dependent variables. Regression tests also prove that AI has a significant impact on demand forecasting, decision making, and textile supply for textile companies [10].

The study presents a *thorough and detailed analysis on the determination and evaluation of the color of textiles made in the laboratory department of a textile dyeing company in Turkey*. In the study of the textile industry company on the finishing of textiles, it was found that classical processes were used to determine the target color of textiles. Then, it is mentioned how the data obtained with the spectrophotometer is used to *evaluate the color of textiles using machine learning methods and artificial neural networks (AI)*. The results obtained show that the data obtained from the hyperspectral camera is evaluated by a long-term short-term memory model, since the spectrophotometer does not give such an accurate result [11].

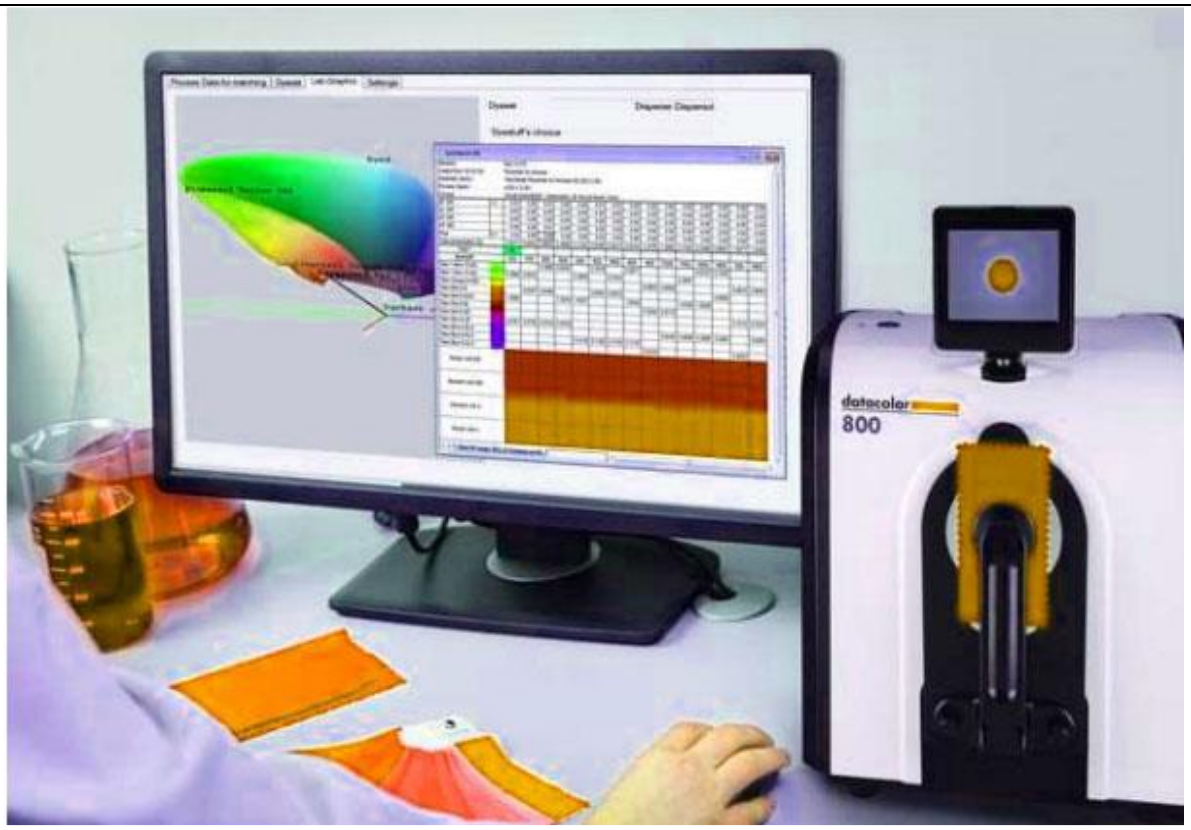

Figure 1. AI colour of textile products [1].

The study demonstrates that *the application of AI in the textile industry enables significant improvements* in efficiency, speed, and reliability in textile material classification, textile defect identification, color detection, and pattern recognition. The integration of AI in the textile industry enables the improvement of analytical analyses and sensors, which allow for better prediction of certain processes and activities, as a result of which reasoned decisions are made based on real-time analyses, which provides opportunities for automated selection, monitoring, quality control and operational efficiency. The study emphasizes the role of AI in the development of the textile industry into a smarter, more efficient and sustainable industry, encouraging new solutions to neutralize disadvantages [12].

The overwhelming majority of the textile industry is managed by people who are not well-trained in information technology, including AI. Future textile professionals can be better prepared to understand information technology and AI, which will help digitize processes in the textile industry and better manage it while identifying the numerous advantages that AI offers. *AI* and its related technologies and their benefits are part of the rapidly developing technologies that have the potential to *optimize the activities of the textile industry* [13].

The *textile industry in India is increasingly using AI and its applications to optimize their operations and activities*. A study on the impact of AI has found its significant role in demand forecasting, sales forecasting and order process management. The study concluded that AI has a major impact on the ordering processes, demand forecasting and sales forecasting of textile companies, which helps in optimizing their overall operations [14].

A study has highlighted the *crucial importance of AI in the textile industry in today's environment*. AI has a positive impact on manufacturing, design innovation, e-commerce, supply chain management by improving operational efficiency and providing opportunities for sustainability. The study identifies the extent of AI application in the textile industry in the context of fashion sustainability. Despite optimistic forecasts regarding the use of AI in the textile industry, available solutions are being used to a limited extent, as companies put economic goals above sustainable development goals [15].

Smart textiles are created by improving technology and implementing innovative textile applications in the textile industry, which is in line with consumer preferences. With the help of AI hardware (neuromorphic computing) and various software modules that mimic the processing capabilities and properties of the neural networks of the human nervous system, the textile sector is enabled to implement innovative and emerging technologies, which contributes to the development of e-textiles. This new generation of AI is rapidly gaining great importance for the textile industry, as it generates the use of new innovative applications. In a *study of the progress of AI in the textile industry for e-textiles*, it was found that when combined with basic architectural elements of artificial neural networks, neuromorphic computing (2D and 3D structures) can *influence new scientific developments in the e-textile sector* [16].

A study found that AI is widely used in more and more areas of business life, which includes the textile industry. With the help of AI, computer parameters for the textile industry have been developed, which will help the emergence of textile garment correction tech-

nology. The article discusses the trend in the development of AI technology and the establishment of computer parameters for textile garments in combination with their development. A textile garment correction system has been created, which can provide a useful reference for the development of AI in the textile industry. Experimental data from the study show that with *optimized design of computer parameters, the creation of an AI-based textile garment correction system helps to integrate AI into textile garment production and improve the efficiency of company management* [17].

AI has great advantages that enable *better system management*, which can lead to *better quality of textiles and better operational efficiency*. The application of AI in textile operations in the textile industry can help solve various problems with good precision. Neural networks, as part of AI, can process various images of textiles, and the computer system can learn billions of combinations of errors that can occur in textiles based on data programming and machine learning. In this way, AI, through a pre-programmed system and image processing, helps to identify defects in yarn. In addition, defects in fabrics can be detected by AI image processing, and through nonlinear regression and ANN (artificial neural networks) can study the structural data of the fabric (bending stiffness and air permeability). AI is also effective in detecting and identifying defects in clothing, which allows for increased levels of production and quality of clothing. *The study also found that the expert system built with the help of AI gives more accurate results than those of human experts, who make more mistakes*. In the case of difficult detection of defects in textile products during dyeing, the expert system built with AI gives more accurate results. ANN and machine learning can be used to prepare recipes for dyeing textile products, as well as to determine colors and shades. AI can also help in identifying textile fibers, increasing productivity, creating safer working conditions in the textile industry [18].

Another study also confirmed that *AI provides new and better opportunities for the development of the textile industry, which has a positive impact on efficiency*. AI influences the various stages of production, optimizing fabric production, color matching and better controlling the quality of textile products. With the development of AI technologies, manufacturers use data to make optimal decisions in real time. With the help of AI, the virtual representation of supply chains is realized with the possibility of reducing textile waste, lower costs and a positive impact on the environment, which is in line with sustainability policies. The integration, transformation of innovations with the help of AI in the textile industry allows companies to increase efficiency. Thanks to AI, textile production has been transformed, including yarn production, fabric quality assessment and color management of textile products, fabric classification, pattern making and supply chain management. AI generates new designs, optimizes processes, predicts trends, and enables the creation of smart clothing with health monitoring capabilities. In conclusion, the authors of the study believe that the *impact of AI on the textile industry is generating innovation, efficiency, and creative opportunities*, while also prompting critical ethical discussions, which is a prerequisite for future research [19].

After the scientific study on the application of AI in the textile industry, it was found that there is a huge impact, expressed in detecting defects at a better speed; integrating and implementing a system (artificial intelligence (AI) and computer vision) for detecting defects in textiles; identifying the advantages and disadvantages of using AI; implementing AI in the textile industry and improving efficiency; exploring the application of AI in the textile industry through mechatronics; more often using AI in companies; in-depth and detailed analysis of textile color determination and evaluation; evaluating textile color using machine learning methods and artificial neural networks (AI); the application of AI in the textile industry and the opportunities for significant improvements; optimizing AI activities in the textile industry; increasingly using AI and its applications to optimize operations and activities in the textile industry; the crucial importance of AI in the textile industry in today's environment; the progress of AI in the textile industry for electronic textiles; the impact on new scientific developments in the electronic textile sector; optimized design of computer parameters, the creation of an AI-based textile garment correction system, helping to integrate AI into textile garment production and improve the efficiency of company management; better system management, which can lead to better textile quality and better operational efficiency; it has been found that the expert system built with the help of artificial intelligence produces more accurate results than those of human experts who make more mistakes; AI provides new and better opportunities for the development of the textile industry, which has a positive effect on efficiency; the impact of AI on the textile industry is to generate innovation, efficiency and creative opportunities.

Conclusion

In conclusion, it has been established that at the current stage of development of digital technologies and innovations, artificial intelligence (AI) is of increasing importance for the development of the textile industry. With the implementation, integration and development of artificial intelligence (AI), companies in the textile industry can optimize their processes, activities, textile products, quality control, thereby increasing the efficiency of their business organization.

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FROM DATA TO MARKETS: HOW AI TRANSFORMS EXPORT CAPACITY AND STRATEGIC DECISION-MAKING OF SMES

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Abstract

This paper examines how artificial intelligence (AI) transforms the export capacity and strategic decision-making of small and medium-sized enterprises (SMEs). Drawing on empirical studies, systematic reviews, and the 2025 WTO–ICC business survey, the analysis shows that AI enhances trade efficiency by automating documentation, improving forecasting, optimising logistics, and strengthening risk management. Evidence from India, Indonesia, the United Kingdom, and Latin America demonstrates that AI capabilities increase export intensity, improve market penetration, and support data-driven strategic decisions, especially under institutional uncertainty. Survey insights reveal that nearly 90% of firms using AI report trade-related benefits, although barriers such as high implementation costs, data-privacy concerns, and limited expertise persist—particularly for MSMEs. The paper outlines practical implications for SMEs, emphasising the need to invest in skills, develop data-governance systems, adopt scalable AI solutions, and leverage AI for market intelligence, logistics automation, and cultural adaptation. Policy recommendations include regulatory clarity, financial incentives, and international cooperation to ensure inclusive AI adoption. Overall, the findings highlight AI's potential to significantly reduce trade costs and strengthen SME competitiveness in global markets.

Keywords: artificial Intelligence, export Capacity,SMEs,trade Efficiency,Data-Driven Decision-Making

Introduction

Artificial intelligence (AI) has emerged as a transformative general-purpose technology affecting production, logistics, marketing and decision-making. Small and medium-sized enterprises (SMEs) stand to benefit disproportionately because AI can help them overcome size-related disadvantages and participate more actively in international markets. Evidence from open-access literature shows that AI can increase productivity, make trade negotiations easier and improve demand forecasting and risk management in supply chains[3]. Neural machine translation, search engines and other AI tools reduce language barriers, help firms identify trends and automate export documentation[3]. These capabilities allow even resource-constrained SMEs to identify emerging opportunities and manage the risks inherent in cross-border trade. Despite these benefits, adoption remains modest. Surveys of SMEs often highlight limited financial and human resources, technical skill shortages and concerns related to data integration, security and privacy[4]. The purpose of this paper is to synthesise recent research on AI, export capacity and strategic decision-making in SMEs, to analyse statistics from the 2025 WTO–International Chamber of Commerce (ICC) business survey and to provide practical recommendations.

AI adoption and export capacity -AI as a driver of international trade -

AI improves efficiency across the export value chain by automating documentation, forecasting demand, optimising logistics and enhancing risk management[3]. Evidence from Indonesia shows that SMEs are still experimenting with AI, while customs authorities already benefit from automated classification and risk assessment[3]. According to the Resource-Based View, AI strengthens firms' unique capabilities; data from 449 Indian exporters demonstrates that AI increases export intensity and market penetration, particularly in uncertain institutional environments[2,4]. AI analytics help firms understand consumer behaviour, reduce transaction costs and manage cultural differences, with stronger effects when cultural distance is high[9].

A systematic review shows that machine learning, NLP and generative AI are the most common tools in SMEs, improving efficiency, decision-making and innovation across business functions[8]. Adoption remains limited due to financial and human resource constraints, requiring investment in infrastructure and skills[9]. In strategic decision-making, AI and big-data analytics support market selection, pricing and resource allocation; UK evidence shows that firms using data effectively are 13% more productive, even though fewer than 1% of SMEs use big-data tools[1,9]. BI systems further complement AI: studies of Paraguayan software firms indicate that although adoption is low, BI is expected to improve export competitiveness, with firms valuing strong cost–benefit ratios, client support and pricing models, and using BI to identify markets and develop pricing and distribution strategies[4].

Empirical evidence: summary of selected studies

Table 1 summarises empirical studies relevant to AI adoption and export capacity in SMEs and multinational corporations (MNCs). The table lists contexts, methods and key findings.

Table 1:

Empirical studies relevant to AI adoption and export capacity in SMEs and multinational corporations (MNCs)

Study & Year	Context and Method	Sample & Data	Main findings (related to export and AI)
Irawan et al. (2025)	Qualitative case study of AI use in Indonesia's export–import process	Interviews with exporters, freight forwarders, logistics companies and customs officials	AI boosts productivity, eases trade negotiations and improves forecasting; customs uses AI for automated classification and risk assessment; exporters are in the experimental stage
Chishty et al. (2025)	Resource-Based View and structural-equation modelling applied to Indian MNC	Survey of 449 exporters in diverse industries; export data from CMIE	AI capabilities positively impact export intensity and market penetration, especially in markets with high institutional uncertainty cultural distance moderates the effect
Le Dinh et al. (2025)	Systematic literature review of AI in SMEs	50 studies (2016-2025)	Identifies machine learning, NLP and generative AI as prominent technologies; emphasises training, infrastructure and partnerships; notes that adoption is hindered by limited resources
Tawil et al. (2023)	Case studies and trend analysis of data-driven decision-making in UK SMEs	85 SMEs in West Midlands, UK	Data science and AI enhance productivity and innovation; 99.9 % of UK firms are SMEs yet adoption of data analytics is <1 %; firms that use data effectively are 13 % more productive
Neubert & Van der Krogt (2018)	Multiple case study of BI adoption in Paraguayan software firms	15 interviews with founders and executives	Few firms use BI, but most expect positive impact on export performance and competitiveness; BI aids market evaluation and pricing decisions
WTO–ICC Business Survey (2025)	Cross-sectional survey of firms using AI in trade	500 + firms across finance, manufacturing and services; 63 % are MSMEs	49 % of firms currently use AI and 79 % trade internationally; 70 % expect AI to reduce trade costs; MSMEs expect larger savings than large firms

This evidence shows that AI adoption is global and affects firms of different sizes. Quantitative studies (e.g., Chishty et al.) demonstrate statistically significant links between AI capabilities and export performance. Qualitative case studies (e.g., Irawan et al. and Neubert & Van der Krogt) provide contextual insights into how AI aids customs clearance, risk assessment and market selection. Survey evidence (WTO–ICC) shows that MSMEs are optimistic about AI's ability to reduce trade costs and increase efficiency[9].

Statistical analysis of WTO–ICC survey data - The 2025 WTO–ICC business survey offers a unique data set on the expected benefits of AI adoption in trade. Sixty-three per cent of respondents were micro, small and medium-sized enterprises (MSMEs), 49 % currently used AI, and 79 % were engaged in international trade[8]. Over 70 % believed AI could reduce trade costs, and MSMEs were more optimistic than larger firms[5]. Table 2 summarises the distribution of firms' expectations regarding trade-cost reductions due to AI and presents weighted-average expected savings. To compute the averages, mid-point values (13 % for 1–25 %, 38 % for 26–50 % and 60 % for >50 %) were multiplied by the proportion of firms in each category. This approach yields a single expected cost-reduction percentage for each firm type and cost category.

Table 2:

The distribution of firms' expectations regarding trade-cost reductions

Cost category	Expected reduction category	Share of MSMEs (%)	Share of large firms (%)	Weighted-average cost reduction (MSMEs)	Weighted-average cost reduction (large firms)
Logistics costs	1–25 % reduction	44	43	**26.7 %**	**22.3 %**
	26–50 % reduction	24	11		
	>50 % reduction	10	6		
Logistics costs	1–25 % reduction	44	43	**26.7 %**	**22.3 %**
Communication costs	1–25 % reduction	29	29	**39.0 %**	**30.0 %**
	26–50 % reduction	24	20		
	>50 % reduction	37	11		
Communication costs	1–25 % reduction	29	29	**39.0 %**	**30.0 %**
Compliance costs	1–25 % reduction	35	46	**28.5 %**	**28.5 %**
	26–50 % reduction	29	29		
	>50 % reduction	15	14		

Interpretation. MSMEs anticipate that AI adoption could reduce logistics costs by roughly **27 %** on average, while large firms expect a **22 %** reduction. For communication costs, MSMEs foresee nearly **39 %** savings compared with **30 %** for large firms. Compliance-cost expectations are similar across firm sizes at about **28.5 %**. These calculations indicate that AI adoption is perceived to deliver substantial efficiency gains, especially for smaller firms whose fixed trade costs (language translation, customs documentation and regulatory compliance) form a larger share of total costs.

Additional survey insights - According to the WTO–ICC survey, almost 90% of firms using AI report benefits in trade activities[6]. The most frequently cited advantage is improved trade efficiency (22%), followed by optimised trade decision-making (14%), a larger foreign customer base (10%), enhanced supply-chain management (9%), and broader import/export product ranges (9% and 8%)[7]. Smaller firms mainly use AI for market intelligence and communication, while larger firms focus on regulatory compliance and trade finance[5]. Key barriers include data-privacy concerns, high implementation costs, and integration challenges; MSMEs also lack in-house expertise and face high upfront expenses[6]. These obstacles highlight the need for targeted support and policy measures.

Practical implications for SMEs

1. Building AI capabilities

To strengthen their AI capabilities, SMEs must invest in skills and training, as adoption is often limited by skill shortages and organisational resistance[5]; partnerships with universities and training providers, supported by public initiatives such as the UK's £24 million programme for AI and data-science skills, can help build the necessary workforce[10]. At the same time, developing a data-driven culture is essential, given that 90% of existing data in the UK has been generated within just the past two years, making accuracy, quality and timeliness critical[3]. SMEs should therefore implement strong data-governance practices, adopt business-intelligence tools to transform raw data into actionable insights, and embed analytics into everyday decision-making to create new revenue streams[10]. Finally, SMEs should choose scalable AI solutions that offer rapid returns, favouring cloud-based systems, low-code tools and SaaS platforms, while carefully evaluating vendors based on price transparency, service quality and sustainable pricing structures[7].

2. Enhancing export capacity

AI can enhance export capacity by supporting market intelligence, customer engagement, logistics automation and regulatory compliance. Through advanced analytics, it enables SMEs to identify new market opportunities, forecast demand patterns and understand foreign customer preferences, allowing firms to prioritise high-potential markets and tailor products accordingly. At the same time, AI reduces trade costs by automating documentation, customs classification, translation and compliance procedures—an effect already visible in Indonesia and in WTO survey evidence, where customs authorities use AI for risk assessment and classification. SMEs that adopt AI-driven logistics solutions can further optimise routing, manage inventories more efficiently and benefit from the significant cost reductions outlined in Table 2. Moreover,

AI helps firms overcome cultural and institutional barriers: in markets with high institutional uncertainty, such as India, AI capabilities have proven especially valuable. By embedding translation tools, sentiment analysis and local-market analytics into their export strategies, SMEs can better adapt to local norms, navigate regulatory complexity and strengthen overall compliance.

Policy recommendations

Governments and international organisations play a crucial role in enabling AI adoption among SMEs by addressing regulatory, financial and institutional constraints. Clear and consistent rules on cross-border data flows, AI ethics and liability are essential, as the WTO–ICC survey shows that data-privacy concerns, security risks and regulatory uncertainty remain major barriers to adoption[7]. In addition to regulatory clarity, financial incentives such as grants, tax credits and subsidised access to AI services can ease the burden of high upfront costs and limited expertise, while technical assistance programmes help SMEs implement AI solutions effectively[5]. At the global level, international co-operation on AI standards, digital infrastructure and capacity-building is critical; the WTO emphasises that AI and trade can jointly promote inclusive growth, allowing SMEs—particularly in low-income economies—to benefit from AI technologies and participate more fully in international markets[7].

Conclusion

AI is reshaping how SMEs access and participate in international markets. Open-access research demonstrates that AI improves export-related processes—from demand forecasting and logistics to compliance—and strengthens strategic decision-making. Empirical studies show positive associations between AI capabilities and export performance[3], while surveys reveal widespread optimism about AI's ability to reduce trade costs[7]. However, adoption remains uneven due to resource constraints, skill shortages and regulatory concerns. SMEs need to invest in skills, develop data-driven cultures and choose scalable solutions to realise AI's benefits. Policymakers must provide clear rules, incentives and support to ensure that AI becomes an engine of inclusive trade growth.

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FOREIGN DIRECT INVESTMENT IN ARMENIA: A FACTOR ANALYSIS OF SECTORAL TRENDS AND ECONOMIC DRIVERS

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Abstract

This research examines the key factors influencing foreign direct investment (FDI) decisions in Armenia, focusing on the real (productive) sector. Employing a combination of graphical, statistical, historical, and comparative methods, the study analyzes investment trends from 2019 to 2024, identifies leading sectors and investor countries, and assesses the impact of macroeconomic indicators. The findings reveal that the energy sector, mining, and financial intermediation are the most attractive for foreign investors, with significant contributions from Russia, the United Arab Emirates (UAE), and Germany. A comparative analysis with Georgia and Moldova highlights the structural and institutional differences shaping investment flows. The study concludes with policy recommendations aimed at improving Armenia's investment climate, including tax incentives for the IT sector and legislative reforms to enhance investor protection.

Keywords: foreign direct investment, investment decision-making, factor analysis, Armenia, economic development, investment climate.

Investments are a pivotal driver of economic development, fostering production growth, job creation, technology transfer, and enhanced competitiveness. For countries with transitional economies like Armenia, foreign direct investment (FDI) is particularly crucial for the inflow of capital, technology, and modern management practices.

In recent years, the Armenian economy has exhibited positive trends, including steady GDP growth, relative stabilization of inflation, and expansion of foreign trade volumes. However, investment processes face numerous challenges, including inflationary pressures, risks of national currency volatility, relatively high interest rates, institutional weaknesses, and regional geopolitical tensions. Under these conditions, understanding the mechanisms and determinants of investment decision-making becomes a significant scientific and practical concern.

The purpose of this article is to conduct a systematic analysis of the dynamics, structure, and determining factors of FDI in Armenia, and to develop recommendations for improving the investment climate. The research is distinguished by its application of a diverse methodological approach, including statistical modeling and comparative analysis with peer countries.

Issues of investment theory and practice are extensively covered in economic literature. The theoretical foundation of this research is based on the following approaches:

Mikhailova and Orlova (2008) define investments as the commitment of resources to generate profit or achieve other positive economic outcomes. According to Harutyunyan (2021), real investments are aimed at the formation of real assets (tangible and intangible) related to operational activities. Investments are classified by purpose (expansion of production, modernization), risk profile (risky, defensive), and other characteristics.

In the Armenian context, studies of the investment climate primarily focus on the legislative framework and macroeconomic indicators. However, a systematic factor analysis, particularly of sectoral distribution and comparative analysis, reveals a gap in the literature. This research aims to address this gap by employing a multifaceted methodology and recent statistical data.

Foreign investment in Armenia exhibited high volatility from 2019-2024.

Table 1.

Dynamics of FDI in Armenia (million AMD)

Year	Total Investment	Direct Investment	Total Investment Growth Rate (%)	Direct Investment Growth Rate (%)
2019	98,442.6	-18,629.4	-	-
2020	-5,836.1	-43,200.9	-105.9	131.9
2021	208,842.0	128,564.2	3678.5	397.6
2022	196,717.5	181,825.2	-5.8	41.4
2023	194,260.0	252,945.3	-1.2	39.1
2024	-113,264.0	-44,779.0	-158.3	-117.7

Source: Statistical Committee of the Republic of Armenia

The significant decline in 2020 was due to the COVID-19 pandemic and the 44-day war. Recovery was recorded in 2021-2023, linked to the influx of businesses and capital relocated to Armenia amid the Russo-Ukrainian war. However, 2024 saw a sharp decline, particularly in the metal ore mining sector.

The sectoral structure of investment flows reveals Armenia's comparative advantages:

1. **Electricity, Gas, Steam, and Air Conditioning Supply (NACE D).** The leading sector in 2019, 2021, and 2022. Dominated by companies with Russian capital ("Gazprom Armenia", "Electric Networks of Armenia").
2. **Financial Intermediation (excluding insurance).** Significant investments from the UAE in 2023.
3. **Metal Ore Mining.** Germany's main investment sector in 2020-2021, but significant capital outflow was recorded in 2023-2024.
4. **Real Estate Activities.** Notable activity in 2022.

The main investor countries (cumulative, 2019-2024) are:

1. **Germany** - 126,252.9 million AMD (primarily mining)
2. **United Arab Emirates** - 107,008.6 million AMD (financial sector)
3. **Russian Federation** - 92,232.9 million AMD (energy)

Significant capital outflow from Russia was observed in 2022-2024, related to the wartime situation and Western sanctions.

Armenia's investment indicators are relatively low in a regional context.

Table 2.

FDI Comparison 2019-2023 (million USD)

Year	Armenia	Georgia	Moldova
2019	-50	1,200	280
2020	-105	900	210
2021	320	1,500	440
2022	480	2,100	-380
2023	650	1,600	360

Source: World Bank, World Development Indicators

Georgia consistently outperforms Armenia due to: A larger market and status as a transport hub, A simpler and more predictable legal and tax system, A more active marketing and investment promotion policy.

Moldova's experience shows that the prospect of EU integration can be a powerful attraction factor.

"Gazprom Armenia" CJSC. A 100% subsidiary of the Russian "Gazprom". Implementing a long-term

investment program of 230 billion AMD until 2030 aimed at modernizing gas transmission and distribution networks. NPV analysis confirms the project's economic feasibility (positive NPV of 21.9 billion AMD).

"Electric Networks of Armenia" CJSC ("ENA"). Owners are the Russian "Tashir" Group (70%) and LIORMAND HOLDING LIMITED (30%). The 2025 investment program amounts to 49.9 billion AMD, aimed at improving grid reliability and creating a ring-feed system in Yerevan.

These cases demonstrate the dominance of Russian capital in Armenia's energy sector, creating risks of dependency and security concerns.

1. Foreign investment in Armenia is characterized by **high volatility** and strong dependence on external shocks (pandemics, regional conflicts).
2. Investment flows are **concentrated in a limited number of sectors** (energy, mining, finance), highlighting the need for greater economic diversification.
3. **Capital outflow from Russia** in 2023-2024 indicates the vulnerability of the country's investment climate and the importance of geopolitical factors.
4. **Comparative analysis** shows that Armenia lags behind Georgia in attracting investment, primarily due to institutional and geopolitical reasons.
5. **Statistical modeling** confirms that traditional macroeconomic indicators (GDP, consumption) lack sufficient explanatory power, necessitating in-depth analysis of non-economic factors.

- **Promotion of the IT Sector for Investment Diversification:** Develop a special tax regime (3-5 year tax holiday) for IT startups, Establish technoparks and incubators for international companies, Strengthen cooperation with the Armenian diaspora in high-tech sectors.1
- **Reform of Investment Legislation:** Extend the duration of the "stabilization clause" from 5 to 7 years, following the Russian example, Simplify licensing and permitting procedures, Strengthen the protection of intellectual property rights.
- **Strategic Reassessment of Investment Policy:** Develop a sectoral specialization strategy focusing on high value-added sectors (IT, biotechnology, toþurism), Create a "one-stop-shop" system for foreign investors, Activate investment marketing in the UAE, China, and South Korea.
- **Strengthening Institutional Capacity:** Establish an independent investment commission for dialogue with investors, Ensure transparency and periodic reporting on investment agreements, Develop a network of local suppliers to strengthen linkages with foreign companies.
- **Improving Labor Force Quality:** Align educational programs with market demands, especially in IT and engineering, Invest in professional retraining and language proficiency programs,

This research demonstrates that improving Armenia's investment climate requires a systematic, multilevel approach combining legislative reforms, development of institutional capacity, and an active marketing strategy. Only the implementation of such an integrated policy can ensure sustainable growth of foreign investment and its effective transformation into economic development.

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THE FUTURE OF MANAGEMENT: AI, AUTOMATION AND NEW TYPES OF LEADERS

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Abstract

This article explores how rapid advancements in artificial intelligence (AI) and automation are transforming the field of management. As organizations adopt intelligent systems, new leadership models emerge, emphasizing adaptability, emotional intelligence, technological competence, and ethical decision-making. The study highlights how these changes reshape organizational structures, workforce dynamics, and leadership roles. It concludes that the future of management depends on the ability of leaders to balance human values with technological innovation.

Keywords: AI; automation; leadership; future of management; digital transformation; organizational change; innovation.

The rapid development of artificial intelligence (AI), automation, and digital ecosystems has redefined the foundations of modern management. Organizations now operate in environments characterized by accelerated technological innovation, data-driven processes, and increased uncertainty. As these forces reshape industries, managerial responsibilities evolve from traditional oversight roles to strategic, technology-enabled leadership. This article examines the multidimensional transformation of management, focusing on structural, cultural, and strategic implications.

AI and Automation as Core Elements of Organizational Transformation

AI and automation increasingly act as catalysts for organizational redesign. Their impact extends beyond operational efficiency to include strategic decision-making, workforce allocation, and long-term planning.

AI systems process complex datasets to support high-quality decisions. Predictive analytics, machine learning algorithms, and natural language processing tools enhance managerial accuracy and reduce uncertainty. Through the use of automation, organizations minimize repetitive tasks, enabling employees to engage in activities requiring creativity, interpersonal communication, and problem-solving. This transformation shifts the managerial focus from supervision to coordination of human–machine collaboration.

Furthermore, AI adoption influences organizational competitiveness. Companies utilizing advanced digital systems gain advantages in market prediction, customer segmentation, and individualized service delivery. Leaders in these environments must therefore integrate data analytics into strategy formation and continually update technological capabilities.

Evolution of Leadership in the Digital Era

The emergence of AI-centered organizations requires leaders to possess new competencies and adopt innovative leadership models. These include the following:

Adaptive and Transformational Leadership

Leaders must guide teams through uncertain and rapidly evolving digital environments. Adaptive leadership emphasizes flexibility, continuous learning, and the capacity to mobilize organizations during transitions. Transformational leadership promotes innovation, inspires employees, and fosters a culture prepared to embrace technological change.

Technological and Analytical Competence

Leadership effectiveness increasingly depends on understanding digital tools. Leaders who interpret data, evaluate algorithmic outputs, and guide digital transformation initiatives contribute more effectively to organizational performance. While leaders need not be programmers, they must be fluent in the language of technology.

AI presents challenges related to transparency, data protection, and algorithmic fairness. Leaders must develop policies ensuring ethical AI use, preventing discrimination, protecting user privacy, and maintaining accountability. Ethical leadership strengthens organizational trust and contributes to responsible innovation.

Despite technological advances, human needs remain essential to organizational function. Emotional intelligence enables leaders to foster resilience, motivation, and cohesion within AI-enhanced workplaces. Human-centered leadership emphasizes empathy, well-being, and the preservation of meaningful work.

Digital transformation reshapes organizational hierarchies. Traditional hierarchical structures give way to more decentralized, flexible, and cross-functional models. AI enables distributed decision-making through real-time analytics, reducing dependency on rigid supervisory chains.

Additionally, workforce composition evolves. Demand grows for digital literacy, analytical thinking, creativity, and collaborative problem-solving. Organizations increasingly value hybrid skillsets that combine technical knowledge with interpersonal capabilities. Talent development strategies prioritize reskilling and upskilling programs, ensuring employees can operate effectively alongside AI systems.

Knowledge-sharing platforms and digital collaboration tools also redefine teamwork. Virtual and hybrid teams become standard, requiring leaders to master remote communication, coordination mechanisms, and digital performance evaluation.

The integration of AI into managerial processes does not eliminate the need for human insight; instead, it transforms managerial identity. Modern management may be understood as a partnership between human cognitive strengths and machine intelligence. AI provides speed, precision, and analytical power, whereas

humans contribute creativity, ethical reasoning, and emotional understanding.

Effective human–technology collaboration requires trust in AI systems. Leaders must cultivate organizational readiness by educating employees about AI capabilities, limitations, and reliability. Transparency in algorithmic processes enhances acceptance and minimizes resistance.

Risks, Challenges, and Strategic Considerations

Although AI offers significant benefits, it also introduces challenges that demand managerial attention. These include:

Job displacement and workforce anxiety resulting from automation-driven restructuring.

Algorithmic bias that may produce unfair or discriminatory outcomes if data quality is poor.

Cybersecurity risks associated with increased digital integration.

Unequal access to digital resources, potentially widening internal skill gaps.

To address these challenges, leaders must implement comprehensive risk mitigation strategies. These include ethical AI guidelines, investment in employee training programs, transparent communication policies, and continuous monitoring of digital systems.

Conclusion

The future of management is characterized by the integration of advanced technologies with human capabilities. AI and automation reshape organizational structures, leadership models, and workforce expectations. Leaders who embrace adaptability, technological fluency, ethical responsibility, and emotional intelligence will be best equipped to guide organizations through the complexities of the digital age. The success of future management depends not on replacing human values with machine efficiency but on combining them to achieve sustainable innovation and organizational resilience.

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HISTORICAL SCIENCES

THE CAUCASUS ISSUE IN THE FOREIGN POLICY OF THE OTTOMAN-SAFAVID-RUSSIAN STATES IN THE SECOND HALF OF THE 18TH CENTURY

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Abstract
The article examines issues related to the foreign policy of the Ottoman-Safavid-Russian states in the second half of the 18th century. In this study, the author argues that the implementation of the Caucasus policy in the 18th century occupied a special place in the geopolitical rivals, the Ottoman, Russian and Safavid states. The Caucasus region, located at the junction of Europe and Asia, where land and water routes to Central Asia, the Near and Middle East passed, played a very important role in the policies of the parties fighting each other. Great Britain, France and other Western states also actively intervened in the internal affairs of the Caucasus.

Keywords: Caucasus issue, foreign policy, competition, Ottoman, Safavid, Russian empire

Introduction

The Caucasus problem had complex features. The role of the Caucasus in the policy of the Ottoman Empire was noticeably felt. This policy can be divided into the following stages according to its importance for the Ottoman Empire and the peoples of the Caucasus:

1) The last quarter of the 15th century - the end of the 17th century;

2) From the Treaty of Istanbul to the Treaty of Sulak (1700-1721);

3) From the accession of Dagestan to Russia to the collapse of the rule of Nader Shah (1722-1747);

1. The collapse of the Ottoman foreign policy in the Caucasus

Each of the above stages was distinguished by its own characteristics, the number of driving forces, goals and objectives, methods and means of achieving them. The first stage (1475-1699), which began with the occupation of the Black Sea fortresses (Feodosia, Sunjik, Taman, Temruk, Azak-Sea of Azov) by the Ottomans and the establishment of control over the Crimea, laid the foundation for the Caucasian policy of the Ottoman Empire and envisaged the solution of the following issues:

1) Taking control of the route along which the pilgrimage to Mecca was carried out and leading to Kabarda;

2) Attacking Astrakhan, Kazan and Central Asia from the North Caucasus in order to unite with the Muslim peoples of the East;

3) Surrounding this state from the north in order to successfully fight the Safavids;

4) Blocking the Russians' path to the Caucasus, preventing them from expanding southward;

5) To force the peoples of the Caucasus to submit to the Ottoman Empire, to strengthen the influence of Islam there.

The Ottomans were unable to achieve these goals. First, because in the second half of the 17th century, the Ottoman ruling circles were preoccupied with the conquest of large territories in Europe, Asia, and North Africa; second, in connection with the crisis that began in the Ottoman Empire in the 1780s and 1790s, the Ottomans suffered a series of heavy defeats at the hands of the European coalition states and Russia, as a result of which they lost Hungary, Transylvania, Slovenia, Right-Bank Ukraine, Podolia, Morea, Dalmatia, and some islands of Azov; third, it was at this stage of the Ottoman Empire's Caucasian policy that its geopolitical rival, the Safavid state, emerged. According to the Treaty of Qasr-e Shirin of 1639, western Georgia and Iraq were considered the territory of the Ottoman Empire [2,157]. The Ottomans' situation was further complicated by the fact that from the middle of the 16th century, Tsarist Russia, along with the Safavids, began to oppose the Ottoman Empire's Caucasian policy. Russia achieved the annexation of Astrakhan in 1556, Kabarda in 1557, and the Turkish fortress of Azov in 1700.

Thus ended the first phase of the Ottoman Empire's Caucasian policy, and the second phase, covering the period from the Treaty of Istanbul in 1700 to the Treaty of Sulak in 1721, began. At this stage, the Ottomans directed the offensive vector of their foreign policy from Europe to the Caucasus, hoping that they would be able to compensate for what they had lost there by occupying the territories of the North Caucasus and southern Russian lands. According to some reports, from the beginning of the 17th century until the Sulak Treaty, Ottoman-Crimean attacks on Kabarda and the southern Russian provinces took place almost without interruption in 1699-1701, 1703-1704, 1707-1708, 1710-1717, 1720-1721.

The most important of the main events characterizing the Caucasian policy of the Ottoman Empire and its consequences for the peoples of the region and for the Ottoman Empire itself was the defeat of the 40,000-strong army of Kaplan Geray Khan in the Battle of Kanjal in Kabarda in 1708. In order to take possession of the Caucasian territories up to the Safavid border, the Ottoman Empire and the Crimean Khanate appealed to the rulers of Dagestan and Kabarda. Some of them went over to the Ottoman side under the leadership of the Kabarda prince Islam bey Misostav, who was from the Baksan community.

At the same time, uprisings began in the Safavid state - in Dagestan and Shirvan. This dealt a blow to the Safavid rule in the Caucasus. In the current situation, A.P. Volynsky's campaign to the Terek was very successful for Russia. As a result of this campaign, the Russian-Ottoman Sulak agreement was signed, according to which Kabarda was considered to be mainly within the sphere of influence of the Ottoman Empire. In August 1721, the Dagestan and Shirvan rebels, led by the Khan of Qazigumukh Surkhay Khan and Davud Bey from Mushkur, captured Shamakhi, abolished Safavid rule there, killed 300 Russian merchants, and also plundered their goods worth 1 to 2 million rubles. Then they turned to the Ottoman Empire for subordination [6,99]. Thus, the Shamakhi massacre of 1721 gave impetus to the re-strengthening of the Caucasian policy of Russia and the Ottoman Empire. The threat of Dagestan and Shirvan falling into the hands of the Ottoman Empire became real. All these factors led Peter I to march to the Caspian Sea in 1722, which marked the beginning of the third stage of the Ottoman Empire's Caucasian policy.

2. Ottoman-Safavid-Russian competition for the Caucasus

This stage of the Ottoman Empire's Caucasian policy, especially its part related to Dagestan, was the most important compared to the previous and subsequent stages. The characteristic feature of the Ottoman Empire's policy at this stage was not only the use of diplomatic, military, political and other acquired means, but also the use of the Sunni sect of Islam to achieve its geopolitical goals [5,6]. After Peter I's campaign to the Caspian coast, Russian troops occupied the Caspian coastal provinces, including Dagestan, up to the Agrakhan Gulf and the Minakand River[4,19].

During this period, the Ottoman Empire also became more active. As a result of the Petersburg Treaty of 1723, Dagestan, the Caspian coastal provinces of Azerbaijan, Gilan, Mazandaran and Astrabad passed into the hands of Russia. The Ottoman Empire was dissatisfied with this treaty. England and France supported the Ottoman Empire. That is why in 1724 the Russian and Ottoman Empires signed the Istanbul Treaty.

The complete weakening of the Safavid state in the 30s of the 18th century led to the emergence of Nadir Khan Afshar on the political scene. In order to return the historical territories of the Safavid state, Nadir began a struggle against the Ottoman Empire. For this purpose, Nadir Khan approached the Russian Empire. On January 21, 1732, he signed the Rasht Treaty with Russia, and on March 10, 1735, the Ganja Treaty, according to which the Russians returned the Safavid lands occupied by the Russians in the Caucasus. However, the Russians did not completely liberate the North Caucasus, but withdrew their troops to the Terek and remained in Gizlar. The fact that the Russians remained in Gizlar, as well as the fact that Nadir Khan Afshar was able to take back the historical Safavid lands from Russia, angered the Ottoman Empire, and they sent the troops of the Crimean Khanate, which was subordinate to the Ottoman Empire, to march on the Caucasus. In 1733, the Crimean Fati Geray attacked the Kuban, Kabarda, Chechnya and Dagestan with an army of 25,000. This was followed in the summer of 1734 by Nadir Khan's first campaign against Shamakhi, which ended with Surkhay Khan's hasty departure from Shamakhi and flight to Avaristan [1,206].

In 1735, the Ottoman sultan ordered the Crimean Khan to march on the Caucasus. The Crimean Khan Qaflan Geray arrived in the Caucasus with an 80,000-strong cavalry. However, he was stopped by the troops of the Shirvan Beylerbey Ali Khan [3,194-200].

In 1735, Nadir Khan also made a second campaign against Shirvan, and by the end of the same year, the Ottoman troops were completely expelled from the Fore Caucasus. The Ottoman Empire, which suffered defeat in the Caucasus, started a war with Russia in 1735-1739 with the instigation and support of Great Britain and France. The Russo-Ottoman War ended with the victory of Russia and the Treaty of Belgrade. However, the neutrality of Kabarda was maintained in the Treaty of Belgrade, which meant the loss of Kabarda for Russia.

During Nadir Shah's campaign in Dagestan in 1741-1743, the rulers here were supported by the Ottoman Empire with various means (money and gifts). In 1747, Nadir Shah was assassinated as a result of an assassination attempt and the state he created completely collapsed, which led to the reactivation of the Ottoman Empire in the Caucasus. The Russian government, which did not want the Ottoman Empire to strengthen its influence in the Caucasus, also took its own measures. Unlike the Ottoman Empire, Russia, which had strengthened its positions in Europe, was able to act more decisively in the Caucasus. Russia began to present itself as the patron of the Caucasian peoples.

Conclusion

Thus, the events that took place from the time of Nadir Shah Afshar's campaign in Dagestan to the consolidation of Russia's position in the region showed that, despite some tactical changes, Caucasian policy remained the focus of the Ottomans. During this period, Russia became closer to the rulers of the Caucasus, especially Dagestan. The Ottoman Empire, on the other hand, sometimes sought mutual relations with Nadir Shah, and sometimes tried to weaken him. Russia, taking advantage of this rivalry, took the first steps to strengthen its position in the region.

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MEDICAL SCIENCES

THE ROLE OF TIME CONTROL IN TREATMENT QUALITY MANAGEMENT

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DOI: 10.5281/zenodo.18004064

Abstract

This study presents a detailed analysis of the duration of various stages of surgical procedures and the intervals between them, based on the data from computerized patient monitoring in operating rooms and intensive care units. It is demonstrated that average time indicators can serve as an effective tool for assessing patients' condition when developing protocols for similar surgical interventions. It is proposed to use statistical data from patients with a favorable perioperative course and successful treatment outcomes. Integrating such objective time standards obtained using computerized monitoring systems into clinical surgical protocols will significantly increase their practical value when analyzing cases with complications. Furthermore, this approach will improve methods for assessing the quality of medical care and expand prognostic capabilities in identifying the causes of complications by analyzing trends in both individual stages of the procedure and the surgical intervention as a whole.

Keywords: surgical stages duration, protocols, computer-monitoring, circulatory disorders.

Funding: This work was performed without external funding.

Conflict of interest: No potential conflict of interest was reported

Modern diagnostic and treatment technologies require precise adherence to protocol recommendations. The recommended protocols of surgical treatment of cardiovascular diseases do not take into account the time of operations and the preparation of patients for them. The significance of assessing the duration of the surgical and postoperative stages of treatment is not reflected in the protocols known to us [1, 2]. Although in practice, the time of cardiopulmonary bypass (CPB), of aortic cross-clamping, and surgery time are generally always evaluated when analyzing the results of surgical treatment [3, 4, 5, 6, 7, 8]. Nevertheless, it must be admitted that systematic research is not being conducted and standards have not been developed.

Known algorithms and assessments of treatment quality do not include the duration of procedures, of treatment stages, intervals between stages, and the operation as a whole. There are no execution time standards even for typical procedures and typical operations. The guidelines for the treatment of acute heart failure of the European Society of Cardiology also do not offer time-based characteristics of procedures and treatment stages, as well as the organization of protocols by computer means [2]. Although such developments can be traced in scientific research [8, 9]. Moreover, the task of achieving the best quality of treatment permeates the entire process of surgery and perioperative care, including regulating staff-patient interaction over time [4, 5, 10, 11, 12, 13, 14, 15]. A large number of works are devoted to increasing the productivity of operating rooms, optimizing clinical outcomes, and patient satisfaction [12, 15, 16]. Special attention is paid to the possibilities of monitoring and other information systems in the organization of treatment during and in the space of interaction between specialists providing operations [3, 10, 17, 18].

Research is underway to predict and optimize the total time of surgical interventions for the rational planning of the clinic's treatment process, including methods of mathematical modeling and artificial intelligence [9, 11, 12, 13, 15, 16, 19, 20], while the duration of the individual stages into which the operational process is actually divided, affecting the overall duration, is little and fragmentary studied [6, 7, 14].

The aim of the study was to compare the duration of the surgical stages and operations in general performed by

one surgeon (and different ones) in homogeneous and different operations. The result of the comparison is a fundamental difference between the compared groups and the division of those for which it is possible to determine standards, as well as an assessment of the information value of the identified operational stages and inter–stage intervals. It is understood that the development of new medical technologies, the improvement of the art of medicine, the emergence of intellectual, informational, technical and technological means, etc. adjusts the estimates of the duration of operational stages, the article focuses on the organization of the clinical and diagnostic process.

Materials and methods. To analyze the effect of the duration of treatment stages on the condition of patients, the results of computer-aided monitoring in operating rooms and the rehabilitation department were used [3, 4, 5]. The case histories of more than 14,000 cardiac surgery patients were analyzed, of which 3,832 computer monitoring protocols were selected for the study, included in the computer database of the automated system for verifying doctor's decisions A.N. Bakoulev Scientific Center for Cardiovascular Surgery for 2008-2022. These patients underwent operations of coronary artery bypass grafting, heart valves replacement, and congenital heart defects repair [18].

The time from the patient's admission to the operating room to the start of cardiopulmonary bypass, the duration of cardiopulmonary bypass, the time after CPB until the patient's transfer to the intensive care unit, and the time of the operation as a whole were recorded. This information is stored in the database (see Fig. 1).

List of patients observed at the DocVue: Brief Information							
Name	Diagnosis	Operation	T total	T before CPB	T no HR	T after CPD	T CPB
Mosk.	Ventric. septal defect	Plastic surgery	3:36	1:36	0:32	1:28	0:56
Mish.	Ventric. septal defect	Plastic surgery	4:48	2:06	1:30	1:12	1:36
Naza.	TAPVD	Radic. correct.	5:36	2:32	0:56	2:08	0:50
Naum.	Aortic valve defect	Re-prosthetics	8:24	2:56	1:52	3:36	3:14
Niko.	Coronary heart disease	Cor. art. bypass	7:28	3:04	1:28	2:56	1:53
Niku.	Mitral valve defect	Valve replacem.	6:08	1:44	2:24	2:00	1:52
Pavl.	Ventric. septal defect	Plastic surgery	2:56	1:44	0:24	0:48	0:35
Pavu.	Atrial septal defect	Plastic surgery	3:36	1:36	0:24	1:36	0:21
Patr.	Mitr. valve defect+IHD	Valve replacem.	7:28	2:32	2:40	2:16	3:28
Petr.	Ventric. septal defect	Plastic surgery	4:00	1:36	0:56	1:28	0:56
Poji.	Tetralogy of Fallot	Radical correct.	4:24	1:44	1:20	1:04	2:06
Popo.	Mitr. +Ao valve defect	Valve replacem.	7:20	2:40	2:32	2:08	1:20
Samo.	Partial atrioventr. canal	Radical correct.	4:32	1:52	1:04	1:36	1:24
Sido.	Common arterial trunk	Radical correct.	6:16	2:32	2:00	1:44	3:14
Sipa.	Ventric. septal defect	Plastic surgery	4:24	1:52	0:56	1:36	1:12
Smir.	Patent ductus arterios.	Band., correct.	5:20				
Soko.	Aortic valve defect	Valve replacem.	6:32	2:16	0:32	3:44	1:46
Soro.	Multiple ASDs	Plastic surgery	6:48	2:16	3:04	1:28	3:44
Star.	Atrial septal defect	Plastic surgery	2:08				0:37

Fig. 1. An example of a database of operated cardiac surgery patients. Columns: 1 - last name, first name, patronymic; 2 - fragment of diagnosis; 3 – short name of operation; 4 – total time of operation (hours:minutes); 5-9 time of the operation stages: 5 – T before CPB - the time elapsed from the patient's admission to the operating room to the start of cardiopulmonary bypass (CPB), 6 – T no HR - the time of absence of rhythmic activity of the heart; 7 – T after CPB - the time from the end of CPB to the end of the operation; 8 – the time of CPB according to the protocol of the operation.

In addition to monitoring and measuring time, ECG, pressure in the heart cavities and main vessels, blood oxygen saturation, temperature, etc., as well as, if necessary, cardiac output and pulmonary artery wedge pressure (for severe patients), etc. were monitored [18]. The control errors corresponded to the monitor ones, for example, data was transmitted digitally over a computer network (SDN) without errors [5]. A fragment of the protocol for collecting and storing data for an individual patient in the database is shown in Fig. 2.

The hemodynamic data of each patient were averaged over the stages and procedures of the operation [5, 18]. The average values for each patient were averaged by type of surgical intervention, operating surgeons, and departments. In addition, the data was summarized for the month, quarter, and year. Figure 3 shows the results of such averaging of the data of 18 patients with hypertrophic obstructive cardiomyopathy (HOCMP) at different stages of surgery. The data of each stage were averaged over 10 minutes of observation.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Hemodynamic monitoring protocol**													
2														
3	Patient's Name	Surgery Data	№ Oper.	Surgeon	Anesth.	Early Childhood								
4	M.	14.09	10(1)	Z.	T.	Departament								
5														
6														
7	TIME	ABP M	PAP M	T1	T2	T1-T2	HR	NBP S	NBP D	NBP M	RR	ST1	SpO2	PAP S
8	14.09 7:48			17,8	16,4	1,4	127	125	51	73	25	0,1	98	
9	14.09 7:57			17,7	16,8	0,9	156	123	84	99	21	-0,1	100	
10	14.09. 8:06			36,5	16,9	19,5	155	124	60	80	28	-0,1	100	
11	14.09. 8:15	17		36,7	33,1	3,5	150				30	-0,2	100	
12	14.09. 8:24	85	4	36,8	34,4	2,3	144	116	53	71	30	-0,1	99	5
13	14.09. 8:33	73	7	36,7	34,9	1,8	138	116	53	71	22	-0,5	100	
14	14.09. 8:42	75	3	36,3	34,9	1,4	148	116	53	71	21	-0,6	100	6
15	14.09. 8:51	59	3	36,1	35,2	1	142	116	53	71	22	-1	100	7
16	14.09. 9:00	72	3	36,2	35,4	0,8	151	116	53	71	24	-1,1	100	6
17	14.09. 9:09	84	6	36,3	35,6	0,7	156	116	53	71	29	-0,2	100	9
18	14.09. 9:18	47	4	36,1	35,6	0,4	160	103	36	56	24	-0,1	100	7
19	14.09. 9:27	31	3	32,7	35	-2,3	0	103	36	56	10			
20	14.09. 9:36	34	3	31,8	33,7	-1,8	0	103	36	56	3		97	
21	14.09. 9:45	46	2	34,3	33,5	0,8	116	103	36	56	20	-1,1	99	5
22	14.09. 9:54	73	3	36,1	34,2	1,9	185	103	36	56	21	-0,9	100	6
23	14.09. 10:03	65	5	36	35	1	161	103	36	56	27	-0,4	100	9
24	14.09. 10:12	76	5	36	35,5	0,5	152	103	36	56	27	-0,1	100	9
25	14.09. 10:21	71	6	36	35,6	0,4	146	105	37	58	25	0	100	9
26	14.09. 10:30	80	5	36	35,6	0,4	148	105	37	58	27	-0,1	100	7
27	14.09. 10:39	85	5	36	35,6	0,4	146	105	37	58	28	-0,3	100	8
28	14.09. 10:48	77	4	36,1	35,7	0,4	155	105	37	58	30	-0,6	100	7
29	14.09 10:57	74		36	35,7	0,3	147	105	37	58	25	-0,7	100	
30	14.09. 11:06	75		36	35,7	0,3	151	105	37	58	25	-0,9	100	
31	14.09. 11:15	71		36,2	35,8	0,5	154	129	92	107	30	-1,1	100	
32	14.09. 11:24	83		36,4	35,8	0,6	151	129	92	107	27	-1,1	100	
33	14.09. 11:33	73		36,6	35,9	0,7	96	129	92	107		-1,3	100	
34	14.09. 11:42	71		36,8	36	0,7	152	129	92	107	28	-1,2	100	
35	14.09. 11:51	66		36,9	36,2	0,7	155	129	92	107	29	-1,3	100	
36	14.09. 12:00							129	92	107				
37	14.09. 12:09							129	92	107				
38	14.09. 12:18													

Fig. 2. An example of a protocol for monitoring hemodynamics during surgery, saved in MS Excel. Time is the date and time of measurement (day, month, hours, minutes), ABP M is the average blood pressure, PAP M is the average pressure in the pulmonary artery, T1, T2, T1–T2, respectively, rectal, skin temperatures and their gradient, HR is the heart rate; noninvasive blood pressure: systolic - NBP S, diastolic - NBP D, mean - NBP M; RR – respiratory rate, ST1 – ST segment, SpO2 – pulse oximetry, systolic pulmonary blood pressure - PAP S.

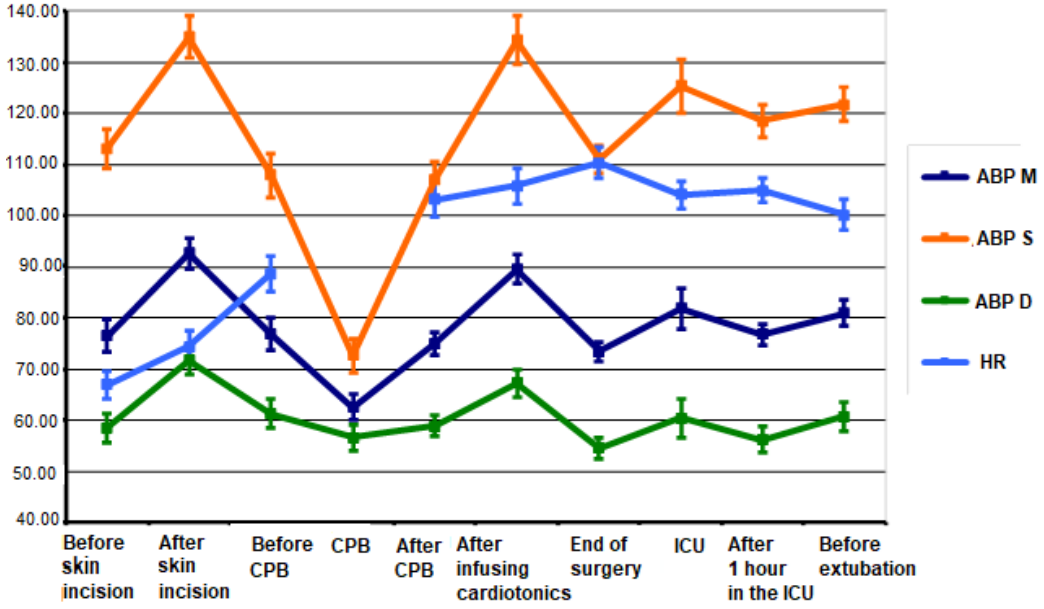

Fig. 3. Trends in the average hemodynamic parameters of patients with hypertrophic obstructive cardiomyopathy: blood pressure – systolic (ABP S), diastolic (ABP D), mean (ABP M), heart rate (HR).

As an example, Table 1 shows a fragment of a statistical analysis of monitoring data in operating rooms for one month.

Table 1.

An example of a statistical generalization for a month of observation of hemodynamic data in the congenital heart defects repair in children from one to two years old

Stages	HR	SpO2	ABP S	ABP D	ABP M	Pulse
Before CPB	107,5±3,3	95,0±0,9	103,7±2,4	56,8±1,1	71,3±1,3	100,8±3,8
Cardiopulmonary bypass (CPB)		92,3±0,9	57,8±1,5	45,9±1,5	50,1±1,4	
After CPB	115,2±2,8	97,5±0,5	101,1±2,0	55,7±1,0	70,6±1,2	113,8±2,3

Fig. 4. Screenshot. Trends of each heart rate cycle when changing pacing modes. Labels: 1 – left ventricular pacing, 2 – no pacing, 3 – right ventricular pacing.

Figure 4 shows the curves of cyclic control (blood pressure: systolic ABP S, diastolic ABP D, and mean ABP M and T=1/HR) of patient C. with aortic valve replacement in the postoperative period during a change of cardiac stimulation modes. 18 minutes of observation: from 13:41 to 13:46, the left ventricle was stimulated, and from 13:46 to 13:52, the right ventricle was stimulated. Changes in mean arterial pressure were mainly determined by changes in diastolic pressure up to 25%, while systolic pressure changed little up to 10%.

A fragment of this patient's data during the shutdown of left ventricular stimulation (13.41.22.66) and the transition to his own rhythm is presented in table 2. Each line contains data on one heart rate cycle. Such cycle-by-cycle monitoring (of each heartbeat cycle) makes it possible to accurately determine the time of transition from one stimulation mode to another and its correlation with hemodynamic parameters [18].

Results of statistical processing of the surgical stages duration. Let us consider the processed data of patients during cardiac surgeries to treat congenital heart defects (atrial septal defect and interventricular septal defect, correction of Ebstein's anomaly, correction of double trunk defect, patent ductus arteriosus, etc.), acquired heart defects (aortic valve replacement, mitral valve replacement), coronary artery bypass grafting, etc. over the course of a year (Table 2). The processing was carried out for each stage for each patient individually and for all groups of patients (a detailed description is given in the publications [4, 5]).

Table 2.

Months	Number of patients	Time from the beginning of monitoring to CPB		Time of absence of rhythmic cardiac activity		Time from the start of the heart to the end of the operation		Total duration of the operation	
		M	Σ	M	σ	M	σ	M	σ
January	122	2:11	0:33	1:15	0:41	1:59	0:44	5:25	1:30
February	104	2:11	0:49	1:08	0:39	2:06	0:44	5:25	1:38
March	108	2:06	0:38	1:08	0:34	1:58	1:00	4:50	1:51
April	151	2:03	0:40	1:01	0:38	1:59	0:56	5:03	1:38
May	189	1:36	0:38	1:10	0:35	1:30	0:38	4:23	1:32
June	155	2:16	0:50	1:13	0:43	2:02	1:16	4:53	2:06
July	109	1:55	0:42	1:07	0:52	1:55	0:52	4:39	1:52
August	126	2:17	0:42	1:11	0:48	1:54	1:00	4:42	1:56
September	153	2:00	0:32	1:04	0:36	1:48	0:51	4:31	1:38
October	185	2:12	0:34	1:10	0:42	2:07	1:07	5:03	1:56
November	97	1:39	0:44	0:59	0:34	1:53	1:12	4:48	1:52
December	146	2:07	0:37	1:09	0:37	1:58	0:53	4:39	1:43
Mean M		2:03	0:40	1:08	0:40	1:56	0:56	4:52	1:46
% standard deviation from the mean σ %		33%		59%		49%		36%	
Error of the mean m		0:03	0:01	0:01	0:01	0:02	0:03	0:05	0:03

Table 2 presents statistical estimates of the duration of the main stages of cardiac surgery with detailed computer monitoring: means (M), standard deviations (σ), errors of the means (m). The following stages are highlighted: before the main stage of the operation (before cardiopulmonary bypass start), the duration was 2:03±00:03 with σ=40 minutes, i.e. the average variation was 33%. The duration of the main stage –cardiopulmonary bypass itself – was 1:08±00:01 (Table 2)

with an average variation of 60% (σ=40 minutes). The duration of the stage after the end of cardiopulmonary bypass until the end of the operation is comparable with the stage before it and was 1:56±00:02 with an average variation of 48% (σ=56 minutes). The average variance in the total duration of operations was 37%, and the total duration of cardiac surgery was 04:52±00:05, which is comparable to international experience. For example, in the study by Costa et al. [6], the duration of cardiac surgery was 06:23±13 with a variance of 49%.

It was found out that the duration of surgeries in operating rooms with computerized monitoring ranged from 2 hours 32 minutes to 10 hours 56 minutes. The period before the start of cardiopulmonary bypass lasted from 32 minutes to 4 hours 48 minutes. The duration of cardiopulmonary bypass (CPB) varied from 16 minutes to 3 hours 12 minutes. The minimum period after CPB until the end of the surgery was 40 minutes, and the longest period was up to 4 hours 56 minutes.

Let us consider, as an example, a detailed analysis of one of the periods of surgical intervention – the time from the start of invasive hemodynamic monitoring to the start of cardiopulmonary bypass, selecting patients for whom this stage lasted more than 2 hours 30 minutes (Table 3; data are given for a month of observation).

Table 3.

An example of the duration of the surgical stages of patients in whom the stage before CPB exceeded 2 hours 30 minutes during a month of observation (hours:minutes)

Stages	Difference in time between the scheduled start of surgery and the actual start	Difference in time from the start of monitoring to the placement of an arterial catheter	Time before CPB	Time of absence of cardiac rhythmic activity	Time after CPB	Total time of surgery	Time from the end of monitoring of one patient to the start of monitoring of the next one
Mean	0:48	0:32	2:55	1:23	2:21	6:41	1:12
Error of the mean	0:52	0:45	0:29	0:41	1:01	1:32	0:45
Maximum	2:39	2:07	4:12	2:51	4:39	10:12	2:15
Minimum	0:09	0:00	2:33	0:45	1:03	4:12	0:45

There were 35 such patients. A period of more than 4 hours was observed in two patients undergoing repeat surgery for total repair of tetralogy of Fallot and total repair of double outlet right ventricle. A period of more than 3 hours was observed in 12 patients, 16% of whom were repeat patients, 40% of whom underwent combined procedures with multivalve replacement and coronary artery bypass grafting and mammary coronary artery bypass grafting. It should be noted that for the stage under consideration before cardiopulmonary bypass, the range of means was small – 16%. For the remaining stages, the range in these patients was more than 40%, and for the first two stages (Table 3, columns 2 and 3), it exceeded the means themselves – 108% and 140%.

Similar operations performed by one surgeon. Let us consider the data on aortic valve replacement surgeries performed by surgeon A.[1] during a quarter (see Table 4). The average variation in the duration of the stages of the operations and the operations as a whole is small and ranged from 4 to 14%. On average, both the stages before and after cardiopulmonary bypass lasted approximately two hours: 02:08±00:05 and 02:18±00:12, respectively. The time of absence of heart rhythmic activity (the main stage – cardiopulmonary bypass lasted on average 01:06±00:04. The total duration of the operation was comparable with the data for the year (see Table 2) and amounted to 05:30±16.

As can be seen from Table 4 (rows "Maximum" and "Minimum"), there were significant differences in the duration of stages and the overall operation. Thus, the duration of the operation ranged from 4 hours to 9 hours 27 minutes. Deviations from the average for shorter operations require study to identify time-saving potential, while for longer operations, an analysis of the causes of complications and the overall organization of the surgical process is needed [4].

[1] The surgeons' surnames are given arbitrarily in the alphabetical order and have no relation to the abbreviation of the real surname.

Table 4.

Database printout. Example of the duration of interoperative intervals and stages of aortic valve replacement surgery performed by surgeon A.

Full name patient	Duration of stages						
	Time between the scheduled start of the operation and the actual start	Time from the start of noninvasive monitoring to the placement of an arterial catheter	Time from the start of monitoring to CPB	Time of absence of cardiac rhythmic activity	Time from cardiac start to the end of the operation	Time from the end of monitoring of one patient to the start of monitoring of the next	Duration of the operation
L.	0:30	0:16	1:52	1:12	3:20	1:12	6:24
M.	0:14	0:24	2:24	1:28	2:24	1:36	6:16
A.	0:30	0:24	1:44	0:48	1:36	1:12	4:08
D.	0:38	0:48	2:08	0:40	1:28	2:16	4:16
H.	0:22	0:32	2:24	0:40	2:08		5:12
K.	0:06	0:24	2:00	1:04	1:20	0:56	4:24
C.	0:04	0:24	1:36	0:32	1:52		4:00
K.	0:44	0:24	2:00	2:00	2:00	5:12	5:12
F.	0:30	0:16	2:40	1:28	2:32	6:40	6:40
I.	0:38	0:08	1:44	1:28	2:24	5:36	5:36
C.	0:54	0:12	2:00	0:48	2:24		5:12
Sh.	2:00	0:12	2:12	1:12	2:00		5:24
D.	1:06		1:48	1:00	2:00	4:48	4:48
J.	0:54		1:48	1:12	1:48	4:48	4:48
N.	0:18	0:27	3:09	1:12	3:00		7:21
Ch.	0:18	0:18	2:42	1:03	5:42		9:27
K.	0:36	0:09	2:06	0:54	1:48		4:48
T.	0:42	0:00	1:48	1:39	2:24		5:51
G.	0:36	0:45	2:33	0:45	1:39	4:57	4:57
Mean	0:36	0:19	2:08	1:06	2:18	3:33	5:30
Error of the mean	0:05	0:02	0:05	0:04	0:12	0:27	0:16
Maximum	2:00	0:48	3:09	2:00	5:42	6:40	9:27
Minimum	0:04	0:05	1:36	0:32	1:20	0:56	4:00

The unfilled cells are due to the fact that it was not possible to reliably estimate the time of this stage.

These are the results of a single surgeon. The obtained data of the stages duration can be used as reference data when planning such surgeries, provided that the surgical risks are low (the surgical period is assumed to be uncomplicated and the outcome is a cure for the patient) [4, 5].

To confirm this conclusion, data obtained from atrial septal defect repair procedures performed by different surgeons were reviewed. The average duration of 16 procedures performed by surgeon B. was 3:47±0:10, with an individual range from 2:26 to 5:24. For surgeon C., the average duration of the stages of 24 similar procedures was 3:42±0:22, close to those of surgeon B.

It was found out that for similar operations performed by one surgeon, the mean time error is:

• the maximum range of duration from the start of non-invasive monitoring to the placement of an arterial catheter ranged from 7 to 19%,

• from the start of invasive monitoring to CPB from 3 to 7%,

• absence of cardiac rhythmic activity from 4 to 18%,

• from cardiac activation to the end of surgery from 9 to 17%,

• the duration of surgery as a whole from 4 to 13% [4, 5].

Comparing these data with the data obtained from similar operations performed by different surgeons, it was determined that in these cases the range was higher.

Similar and different operations performed by the same surgeon. Let us compare the duration of operations performed in the same department by two surgeons, G. and D., when they were first assistants and when they performed the operations independently (Tables 5a and 5b). Tables 5a and 5b show that the difference in time between the scheduled start of the opera-

tion and the start of the patient's monitoring was significantly smaller when they operated as first assistants (by 57% and 58%, Table 5a and 57% and 44%, Table 6b). Surgeon G. spent less time installing an arterial catheter when he operated as first assistant (by 17% and 8%), while surgeon D. spent more time in a similar situation (by 9% and 22%). As this result was observed both in the case of similar surgeries (ventricular septal defect repair, Table 5a) and in different surgeries (Table 5b), then it most likely characterizes the personal characteristics of the surgeons. Two more interesting points should be noted in these tables. The time of CPB in similar surgeries (ventricular septal defect repair, Table 5a) was practically the same as the annual average (Table 2), lasting on average approximately one hour, and did not depend on the operating team, in which surgeons G. and D. acted as operating surgeons or assistants.

At other stages before and after CPB, the time expenditure of surgeons G. and D., if they acted as assistants, increased to 20% for similar operations (Table 5a) and up to 40% for different ones.

Table 5a.

Duration of stages and interstage intervals in patients with ventricular septal defect repair surgery (hours: minutes).

Operating surgeon	Number of patients	Number of patients with complications/% of total number of patients	Difference in time between the scheduled start of surgery and the actual start	Difference in time from the start of monitoring to the placement of an arterial catheter	Time from the start of monitoring to CPB	Absence of cardiac rhythmic activity	Time from cardiac start to the end of surgery	Time from the end of monitoring of one patient to the start of monitoring of the next	Total duration of surgery
Surgeon G. - assistant	4	-	00:33 ±00:06	00:24 ±00:18	02:28 ±00:08	01:01 ±00:11	01:49 ±00:11	01:05 ±00:01	05:19 ±00:13
Surgeon G. - lead surgeon	6	-	01:19 ±00:24	00:29 ±00:05	01:5 3±00:03	01:05 ±00:08	01:21 ±00:14	01:12 ±00:00	04:20 ± 00:18
Difference in %*			-58	-17	23	-6	26	18	-10
Surgeon D. - assistant	10	-	00:33 ±00:04	00:32 ±00:04	02:2 0±00:07	01:11 ±00:04	01:49 ±00:08	01:18 ±00:20	05:12 ±00:11
Surgeon D. - lead surgeon	10	2/20%	01:10 ±00:13	00:29 ±00:02	01:46 ±00:06	01:08 ±00:03	01:07 ±00:06	01:56 ±00:34	04:0 3±00:09
Difference in %**			-52	9	24	4	38	22	-26

The difference in %* shows how much more or less (-) time Surgeon G. spends on the surgical steps as the first assistant compared to performing them independently.

The difference in %** shows how much more or less (-) time Surgeon D. spends on the surgical steps as the first assistant compared to performing them independently.

Table 5b.

Duration (hours: minutes) of surgical stages and inter-stage intervals in children of the first year of life, operated on in one department

Operating surgeon	Number of patients	Number of patients with complications/% of total number of patients	Difference in time between the scheduled start of surgery and the actual start	Difference in time from the start of monitoring to the placement of an arterial catheter	Time from the start of monitoring to CPB	Absence of cardiac rhythmic activity	Time from cardiac start to the end of surgery	Time from the end of monitoring of one patient to the start of monitoring of the next	Total duration of surgery
Surgeon G. - assistant	51	7/14%	00:27 ±00:12	00:31 ±00:10	02:23 ±00:19	01:38 ±00:20	01:43 ±00:28	01:47 ±00:44	05:51 ±00:48
Surgeon G. - lead surgeon	36	2/4%	01:04 ±00:10	00:3 4±00:04	01:45 ±00:05	00:51 ±00:03	01:16 ±00:06	01:47 ±00:08	03:35 ±00:10
Difference in %*			-57	-8	27	42	13	47	0
Surgeon D. - assistant	35	3/9%	00:33 ±00:09	00:36 ±00:05	02:22 ±00:14	01:11 ±00:05	01:48 ±00:10	01:53 ±00:28	05:33 ±00:20
Surgeon D. - lead surgeon	22	3/14%	00:59 ±00:14	00:28 ±00:02	01:45 ±00:07	00:57 ±00:04	01:14 ±00:06	02:12 ±00:28	03:51 ±00:14
Difference in %**			-44	22	27	20	31	40	-14

References * and ** correspond to Table 5a.

Characteristics of the time between surgical stages. Summarizing the data for a year of observation showed that the duration of the stage from the time when the patient was admitted to the operating room according to the schedule until connection to monitoring (before the installation of ECG electrodes, an SpO2 sensor, and a blood pressure cuff) was quite long: the indicators deviate from the mean value by an average of 92% (mean duration 50±3 minutes). For similar procedures performed by the same surgeon, for example, during aortic valve replacement, this time averaged 36±5 minutes (Table 4). The range of time for aortic valve replacement surgeries ranged from 4 minutes to 2 hours, and for atrial septal defect repair, from 4 minutes to 1 hour 38 minutes. These data demonstrate significant potential for shortening of this stage. The importance of determining the onset of surgery has also been emphasized by other researchers. For example, Vladu et al. [9] are developing special computational algorithms to control the start time of surgery to improve the efficiency of operating room use.

The duration of the surgical phase from the start of noninvasive monitoring to arterial catheter placement averages 27±1 minutes (maximum 4 hours 21 minutes, minimum 12 minutes). This phase characterizes the time elapsed from the moment monitoring is established to the moment the arterial catheter is inserted—the start of invasive blood pressure measurement, which is the actual start of the surgical procedure—the invasive intervention. It is necessary to investigate the causes of prolonged expectation time for patients already admitted to the operating room before procedures begin, so that measures can be taken to streamline this process.

These studies echo the work of Costa et al. [6], who examined the time spent in the operating room and the time of the surgical procedure itself. They identified patterns in the duration of surgical stages which may aid in operating room planning and reduce delays.

The intervals between the end of monitoring for one patient and the start of monitoring for the next one, i.e., the interval between surgeries, on average 1 hour 12 minutes (±3 minutes). The individual range, from 12 minutes to 5 hours 4 minutes, indicates the need for the analysis of potential time reserves. It should be noted that computerized monitoring allows for an accurate assessment of all stages and interstage intervals, as opposed to expert assessment of time elapsed [21].

An example of similar surgeries. Let's consider the data of two patients with aortic defects, operated on by the same surgeon (Fig. 4).

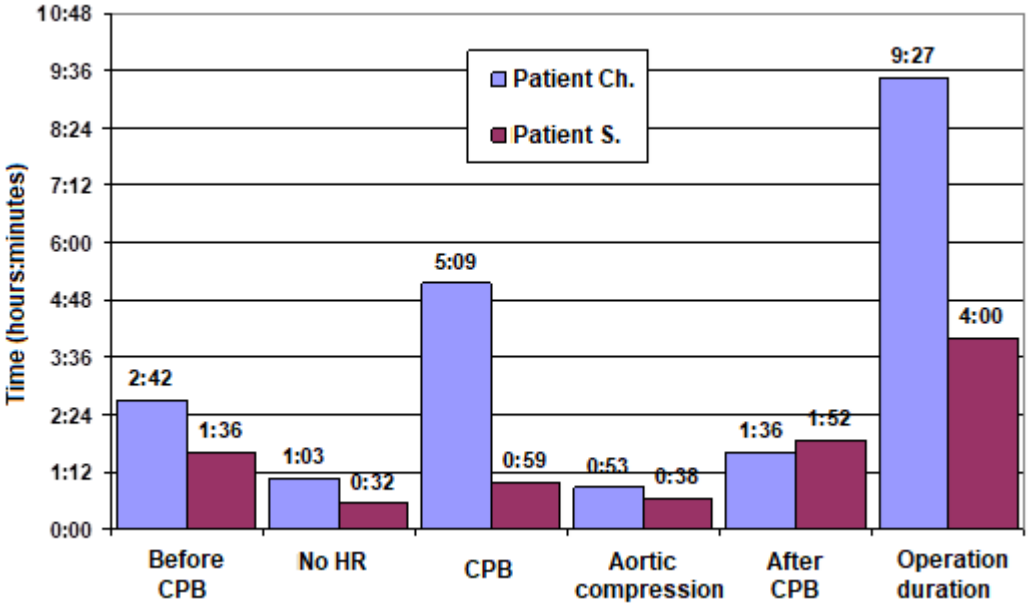

Fig. 4. Duration of the surgical stages of aortic valve replacement in patients Ch. and S.

Patient Ch., 52 years old, with calcified aortic valve disease (stenosis and insufficiency grade 2), with paroxysmal atrial fibrillation, underwent aortic valve replacement surgery with a mechanical prosthesis AST No. 25 under CPB, hypothermia and pharmaco-cold cardioplegia (Fig. 5).

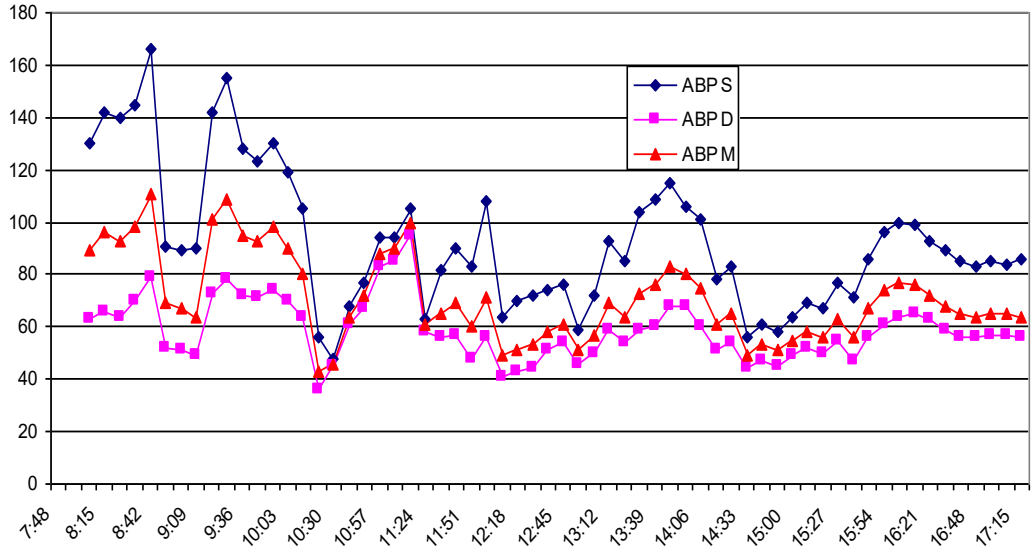

Fig. 5. Hemodynamic trends during aortic valve replacement surgery in patient Ch.: systolic (ABP S), diastolic (ABP D) and mean (ABP M) blood pressure.

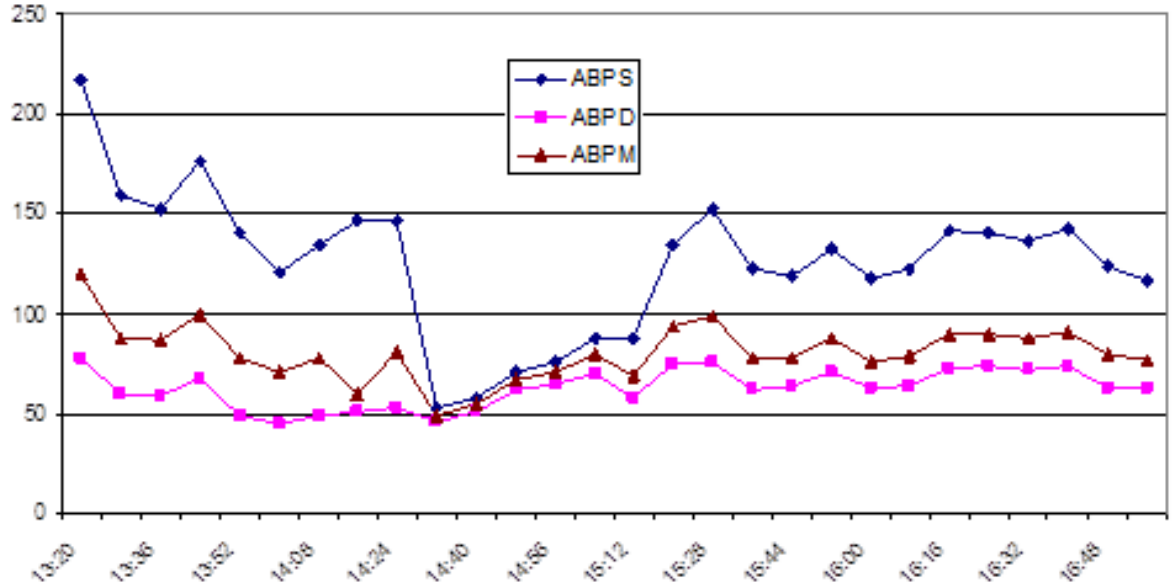

Fig. 6. Hemodynamic trends during aortic valve replacement surgery in patient S.: systolic (ABP S), diastolic (ABP D) and mean (ABP M) blood pressure.

Patient S., 52 years old, with aortic valve insufficiency, underwent a similar operation of aortic valve replacement with a mechanical prosthesis AST No. 23 (Fig. 6).

In Fig. 4, the last columns show the duration of the surgical intervention for patient Ch. (duration of the operation 09:27) and S. (04:00). The difference in the duration of the operation was determined by the fact that the stages before cardiopulmonary bypass and cardiopulmonary bypass stage in patient Ch. were longer by 01:06 and 04:10, respectively. The longer period of cardiopulmonary bypass was due to an episode of rhythm disturbance - atrial tachyarrhythmia with a drop in hemodynamic parameters - occurring during the hemostasis stage. Due to this, cardiopulmonary bypass was restarted. During an attempt to end CPB, multiple episodes of rhythm disturbance with a drop in hemodynamic parameters occurred. The rhythm was restored with defibrillation and medication. As a result, in the early postoperative period, patient Ch. required greater cardiotonic support: adrenaline at a dose of 0.085 mcg/kg/min and dopamine at a dose of 5 mcg/kg/min, in contrast to patient S., who received a minimal dose of dobutamine (3.65 mcg/kg/min) in the early postoperative period.

Hemodynamic analysis. The duration of the surgical period significantly affects the postoperative patient's condition [5, 8]. Data processing showed that the patient's hemodynamics is affected by the duration of the following stages: cardiopulmonary bypass, before cardiopulmonary bypass, especially the part from admission to the operating room until intubation and after the main stage of the operation until its completion [4, 5]. As an example, we present the monitoring data of patients P. (operative duration 03:36) and B. (operative duration 05:36), who ventricular septal defect repair under cardiopulmonary bypass and pharmaco-cold cardioplegia (Table 6). Rows 2-4 present the monitoring data for patient P., and rows 5-7 for patient B. For patient B., the time before the start of cardiopulmonary bypass (CPB) was 01:12, the CPB time was 00:26, and the post CPB time was 00:32 longer than for patient P. This affected his hemodynamics by a decrease in his arterial pressure: ABP S, ABP D and ABP M by almost half, and SpO2 by 15% during cardiopulmonary bypass, an increase in heart rate by 15%, and an increase in pulmonary artery pressure (PAP S) by 43%, PAP M by 85%, and PAP D by three times after the main stage of the operation (see Table 6).

Table 6.

A fragment of statistical analysis of monitoring data for patients with short and long surgical periods

Patients	Stage	HR	SpO2	ABP S	ABP D	ABP M	PAP S	PAP D	PAP M
P.	Before CPB	115,4±4,3	99,8±0,2	109,2±4,4	59,4±2,9	77,9±3,4	6,8±0,2	2,5±0,3	4,3±0,3
	CPB		96,6±2,2	72,8±3,4	51,2±1,9	63,2±2,6	7,0±1,0	3,1±0,6	4,9±0,6
	After CPB	122,7±1,8	100,0±0,0	117,0±2,4	65,1±1,4	87,1±1,7	9,0±0,2	5,6±0,2	7,2±0,2
B.	Before CPB	127,4±2,8	99,2±0,2	96,2±1,3	56,4±1,2	69,9±1,6	6,8±0,7	2,2±0,5	3,9±0,4
	CPB		84,6±2,2	**44,1±4,9**	**31,4±0,9**	**35,9±1,4**			4,0±1,5
	After CPB	146,1±1,5	99,0±0,1	99,9±1,4	57,3±1,3	69,9±1,5	9,7±2,1	8,6±0,5	7,2±0,2

Statistical verification of the last result was impossible, since the patients' condition significantly depends on the administered potent drugs. The administration of potent drugs is not monitored, and at the same time, their type and doses vary greatly from patient to patient and even during treatment of the same patient. This circumstance excludes the feasibility of statistical analysis for large samples and makes the results of an individual approach more effective [3, 5, 10, 18, 22]. Long-term observations have convinced us that an increase in the duration of operations increases the risk of complications, especially if the treatment is accompanied by high doses of cardiotonics in combination with other complications [5].

Therefore, it is advisable to monitor and use objective computer-based monitoring of patient condition parameters to provide treatment, as these parameters also determine the timing of surgical treatment stages. For this purpose, it is necessary to develop and include appropriate standards in protocols and, even more importantly, to present trends in patient condition parameters (clinical, hemodynamic, and biochemical) as they depend on time, as well as the course of the surgery itself, also over time, when analyzing complications [3, 5, 10, 18, 22].

To summarize, we hope that in the near future, operating room information systems will precisely control all surgical conditions: the parameters of the surgical equipment, the premises, the actions and physical condition of the medical team and, of course, the objective condition of the patient [9, 16, 18, 23]. With cycle-by-cycle analysis, it is possible to control thousands and hundreds of thousands of measurements and calculations in real time, therefore the dispersion and analysis of some stages of operations required long-term precision statistical and clinical-physiological data analysis [10, 18, 22].

Thus, A.N. Bakoulev Scientific Center for Cardiovascular Surgery implemented planned, ongoing computer-based monitoring and analysis of the duration of surgical stages, including average values, variance, and determination of dependencies on the severity of the initial condition, type of anesthesia, etc. As a result, we obtained reference values for the duration of surgical stages for orientation and inclusion in treatment protocols.

Conclusions. The average duration of the identified surgical stages is compact and stable, consistent with the patient's condition and the best international practices.

The individual variation in surgical duration and surgical stages varies greatly from patient to patient compared to the average values. Therefore, for complex cases, detailed personalized monitoring of the stages, taking into account hemodynamic status, is necessary [3, 5, 10].

It should be noted that the variability in the duration of the stages of the surgical process, assessed using computer monitoring, indicates that:

- the quality of diagnostic preparation for surgery and an insufficiently accurate diagnosis lead to additional time expenditure and changes to the preliminary treatment plan;
- an increase in the time from the patient's arrival in the operating room to the start of the surgical process (induction of anesthesia) leads to a deterioration in the patient's condition.

Treatment protocols for cardiovascular diseases, both surgical and medical, should take into account the time required for treatment stages and procedures. This will improve quality assessments and prognostic capabilities for both individual stages and for procedures as a whole, compared to currently used methods [22].

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PEDAGOGICAL SCIENCES

IMPLEMENTATION OF INTRA-SUBJECT CONNECTIONS DURING TEACHING GEOMETRIC CONCEPTS

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Abstract
This article examines the role of interdisciplinary connections in teaching geometric concepts during the training of primary school teachers at pedagogical universities. It also identifies ways to implement these connections in the course "Basic Geometric Concepts and Propositions."

Keywords: primary school, interdisciplinary connections, geometry, spatial representation, learning

Introduction

The basis for the subsequent stages of students' mathematical education is the knowledge, skills and abilities acquired by them in primary school. Therefore, the organization of teaching mathematics in primary school in accordance with modern requirements requires the teacher to have deep knowledge of the essence of mathematical concepts and facts, as well as high pedagogical skills. Every elementary school teacher who will teach mathematics must be familiar with its general ideas, be able to see the connections of these ideas with the educational material being studied, and be able to identify these connections if necessary.

Every primary school teacher should know that the mathematics he teaches during his school years forms the scientific and theoretical basis of the mathematics he teaches in primary school. Therefore, it is extremely important that every subject taught in higher education, especially mathematics, is based on intra-subject connections. In addition to establishing fundamental mathematical concepts such as geometric concepts, elementary school introduces students to the elements of geometry and develops spatial awareness and logical reasoning abilities. All this implies that the mathematical training of primary school teachers should be especially high. Every primary school teacher, in addition to a deep knowledge of the scientific and theoretical aspects of simple geometric concepts, must also know simple spatial figures, their properties, have the skills to describe simple spatial figures on a plane, be able to justify the choice of a particular mathematical solution method and be able to identify relationships between simple spatial figures in the process of solving a problem [1,237].

As is known, in elementary school simple geometric concepts are given to students without a serious logical definition of these concepts, and in most cases - in a ready-made form. Therefore, these concepts must be completely logically understandable to the teacher. In addition, a primary school teacher must be able to use the subject of mathematics taught by him as a tool for educating students, broadening their horizons and increasing interest in mathematics [2,9]. All this requires significant methodological and mathematical preparation from the teacher. These requirements for mathematical training and professional skills of students studying in the specialty "Primary school teacher" determine the need to teach geometric concepts based on intra-subject connections. A student studying in this specialty must understand that, knowing at the required level the scientific and theoretical basis of each geometric concept that he will teach to schoolchildren, he will be able to find the most effective way to explain this concept. Therefore, every future primary school teacher must take into account that the specific geometric concept that he will teach has a scientific and theoretical basis, and he must be ready to substantiate this concept from a scientific and theoretical point of view in a future lesson. This can only be achieved if students are trained in geometry during the learning process at the level of modern scientific, pedagogical and methodological requirements, including taking into account intra-subject connections [3,5]. The use of spatial relationships when teaching the elements of geometry is very important, especially in the stereometry section. The section of stereometry includes the study of three-dimensional figures and their properties. Using spatial relationships when teaching this section is important to deepen students' spatial awareness and increase their understanding of the subject [4,112].

The use of spatial relationships when teaching the section of stereometry is mainly manifested in the following:

– spatial imagination: visual aids (models, drawings) should be used to help students imagine three-dimensional objects. This helps to understand the shape, volume and other properties of objects.

– analysis and comparison: using spatial relationships, you can compare the properties of different objects (for example, prisms, cylinders, cones). This helps learners understand the similarities and differences between objects.

– solving geometric problems: by applying non-standard approaches to solving problems related to stereometry, more effective solutions can be found. For example, calculating volume, finding surface area, etc.

– interactive teaching methods: the use of interactive methods in lessons allows students to be more actively involved in the learning process. This facilitates the application of non-standard ratios in real life.

– practical tasks: students should be asked to apply the learned theory by offering practical tasks, for example, on making or modeling three-dimensional figures.

Conclusion

Methodically considering the ways of using intra-subject connections when teaching geometric concepts in the process of training pedagogical personnel in the specialty "Primary school teacher", we come to the following conclusions:

– it is extremely important that the teaching of each subject in higher education, especially geometry, is based on intra-subject connections.

– the use of intra-subject connections when teaching geometry develops students' spatial perception, helps them better understand the subject and apply it in practice. This approach also creates conditions for increasing the interest and interactivity of lessons - the use of intra-subject connections when teaching basic geometric concepts closely contributes to the teaching of other subjects.

- the use of intra-subject connections when teaching geometry increases the level of students' assimilation of the section of stereometry, expands their spatial representations, which leads to an increase in the quality of teaching the subject and the training of teaching staff in general.

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PHILOLOGICAL SCIENCES

INTERLANGUAGE DEVELOPMENT IN ADULT EFL LEARNERS: A LINGUISTIC PERSPECTIVE

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Abstract

Interlanguage theory provides a central framework for understanding how second language learners construct and develop linguistic systems over time. This conceptual study examines interlanguage development in adult EFL learners from a linguistic perspective, emphasizing grammatical, pragmatic, and developmental dimensions of learner language. Drawing exclusively on selected theoretical and empirical studies in second language acquisition, the article synthesizes research on grammatical growth, pragmatic transfer, variability, and fossilization in adult interlanguage. The analysis highlights that adult learner language is systematic, rule-governed, and shaped by instructional context, social interaction, and cognitive maturity. Rather than viewing persistent non-target-like forms as deficiencies, the study interprets them as reflections of ongoing interlanguage restructuring. The findings suggest that meaningful linguistic development in adult EFL learners emerges through interaction, feedback, and form–meaning integration. The article concludes by discussing pedagogical implications for EFL instruction and emphasizing the importance of recognizing interlanguage as a dynamic linguistic system.

Keywords: Interlanguage; Adult EFL Learners; Second Language Acquisition; Linguistic Development; Grammatical Growth; Pragmatic Transfer

1. Introduction

Interlanguage theory constitutes a foundational framework in second language acquisition research, emphasizing learner language as a systematic and evolving linguistic system rather than a collection of random errors. Adult EFL learners, in particular, offer valuable insight into interlanguage development due to their cognitive maturity, established first-language systems, and extensive exposure to formal instruction. Understanding how adult learners construct and modify interlanguage systems is therefore essential for both linguistic theory and pedagogical practice, as it enables researchers and educators to interpret learner output as evidence of developmental processes rather than linguistic failure.

Recent studies in applied linguistics highlight that adult language learning is shaped by multiple interacting factors, including instructional context, social interaction, and technological mediation (Nuri, 2024; Ismayilli & Nuri, 2025). In contemporary learning environments, learners' engagement with digital platforms, mobile applications, and social networks has further influenced how linguistic input is processed, negotiated, and internalized. Such mediated interactions provide increased opportunities for exposure, feedback, and communicative practice, thereby contributing to variability and restructuring within adult interlanguage systems (Nuri, 2024). This variability should not be interpreted as inconsistency, but rather as a reflection of the dynamic and adaptive nature of interlanguage development.

Moreover, challenges encountered by adult EFL learners—such as persistent grammatical inaccuracies, limited morphological marking, and pragmatic transfer from the first language—underscore the need for a linguistic interpretation of learner language rather than a deficit-based one (Alaviyya & Babayev, 2023). From this perspective, non-target-like forms may indicate developmental stages, processing constraints, or stabilization processes, including fossilization, rather than an absence of linguistic competence. Recognizing these patterns as systematic allows for a more nuanced understanding of adult second language development.

This article adopts a linguistic perspective to examine interlanguage development in adult EFL learners by synthesizing theoretical and empirical studies in second language acquisition. Focusing on grammatical growth, pragmatic competence, and developmental variability, the paper aims to demonstrate that adult interlanguage reflects rule-governed linguistic competence shaped by cognitive, social, and instructional influences. By foregrounding the systematic nature of adult learner language, the study seeks to contribute to ongoing discussions on interlanguage theory and to inform more effective pedagogical approaches in EFL contexts.

2. Interlanguage and Adult Second Language Acquisition

Interlanguage was initially conceptualized as an independent linguistic system that emerges as learners progress toward the target language. Schumann (1974) emphasized that adult second language acquisition shares features with pidginization processes, particularly when linguistic development stabilizes at non-target-like stages. This view challenged earlier assumptions that adult learners simply failed to acquire native-like proficiency and instead framed learner language as developmentally constrained.

Instructed learning contexts further influence interlanguage development. Long (1987) argued that instruction plays a crucial role in shaping interlanguage by directing learners' attention to specific linguistic forms and facilitating restructuring. Adult learners,

who often rely on explicit knowledge and metalinguistic awareness, may benefit from such instruction, although their interlanguage systems may still exhibit fossilized features.

Empirical research confirms that adult interlanguage evolves through identifiable stages marked by grammatical growth and communicative adaptation. For instance, spoken interaction has been shown to promote grammatical development by providing opportunities for hypothesis testing and feedback (Thamrin, 2025). Such interaction-driven development highlights the importance of meaningful communication in sustaining interlanguage change. Moreover, adult learners' ability to reflect on language use can facilitate conscious adjustment of emerging linguistic forms. These processes collectively underscore the adaptive nature of adult interlanguage development.

3. Linguistic Features of Adult Interlanguage

3.1. Grammatical Development

Grammatical development constitutes a central dimension of interlanguage research. Studies on adult learners demonstrate that grammatical growth is gradual and often non-linear, with learners exhibiting partial mastery of structures such as articles, tense, and agreement. Cognitive constraints and first-language influence may shape how grammatical rules are internalized, as evidenced in analyses of article use among adult learners (Mizuno, 1999). Furthermore, learners' grammatical development is influenced by instructional approaches and communicative practices. Communicative Language Teaching techniques, while promoting fluency, may not always ensure grammatical accuracy unless supported by form-focused instruction (Javid, 2023). As a result, adult learners often develop stable yet non-target-like grammatical patterns that reflect ongoing interlanguage restructuring. Such patterns indicate selective attention to form and meaning rather than incomplete acquisition. This balance between communicative competence and linguistic accuracy is a defining feature of adult interlanguage systems.

3.2. Pragmatic Transfer and Discourse Use

Pragmatic competence represents another critical aspect of interlanguage development, as it involves learners' ability to use language appropriately across diverse social and communicative contexts. Adult EFL learners frequently transfer pragmatic norms from their first language, resulting in non-target-like realizations of speech acts, politeness strategies, and discourse conventions. Dogancay-Aktuna and Kamisli (1997) demonstrated that even advanced learners may experience pragmatic transfer, highlighting the persistence of interlanguage features beyond grammatical domains and underscoring the relative resistance of pragmatic competence to formal instruction. Communication strategies further reveal how learners compensate for linguistic gaps in interlanguage production and maintain communicative effectiveness. Research on Chinese EFL learners illustrates that strategic language use—such as paraphrasing, approximation, and discourse negotiation—reflects underlying interlanguage competence rather than communicative failure (Si-Qing, 1990). These strategies indicate learners' active engagement with meaning construction and their ability to manage interaction despite limited pragmatic resources.

Moreover, pragmatic development in adult interlanguage is closely linked to discourse context and exposure to authentic interaction. Learners' sensitivity to contextual variables, including power relations and social distance, often develops unevenly, contributing to pragmatic variability across situations. Such findings underscore the importance of analyzing interlanguage within authentic discourse contexts, where pragmatic choices emerge dynamically through interaction rather than through isolated linguistic forms.

4. Variability and Individual Differences

Interlanguage development is characterized by considerable variability across learners and contexts. Individual learner profiles reveal distinct developmental trajectories influenced by factors such as amount of exposure, motivation, cognitive style, and learning strategies (Balenović, 2017). Adult learners, in particular, may display fluctuating performance depending on task demands, attentional focus, and communicative settings, alternating between more target-like and non-target-like forms. Such variability reflects the dynamic nature of interlanguage rather than instability or inconsistency. In addition, instructional context and mode of interaction play a significant role in shaping individual differences in interlanguage development. Learners may demonstrate higher levels of accuracy in controlled or form-focused tasks while relying on simplified structures in spontaneous communication. This context-dependent variation highlights the interaction between linguistic knowledge and performance conditions in adult second language use.

Social and cultural dimensions further contribute to interlanguage variability. Language learning is embedded in broader social practices, including engagement with cultural narratives, identity construction, and communicative norms (Nuri et al., 2025). These dimensions interact with linguistic development by influencing learners' pragmatic choices and discourse patterns, reinforcing the view that interlanguage is shaped by both structural and sociocultural factors operating simultaneously.

5. Pedagogical Implications

Recognizing interlanguage as a systematic linguistic phenomenon has important implications for EFL instruction, particularly in adult learning contexts. Teachers should interpret learner errors not as signs of failure, but as indicators of developmental stages within an evolving interlanguage system. Such an understanding encourages more supportive and diagnostic feedback practices that focus on guiding learners toward restructuring linguistic forms rather than merely correcting surface-level inaccuracies.

Instructional practices that integrate interaction, feedback, and multimodal support can play a crucial role in facilitating interlanguage development. Meaningful interaction provides learners with opportunities to test hypotheses about the target language, while feedback draws attention to form–meaning relationships. Multimodal resources—such as gestures, mimics, and

visual cues—further enhance comprehension and retention by reinforcing linguistic input through embodied and contextualized learning experiences (Ismayilli et al., 2025). These strategies are particularly effective for adult learners, who benefit from explicit connections between linguistic form and communicative function.

Additionally, technology-mediated learning environments offer expanded opportunities for sustained exposure, authentic interaction, and learner autonomy. Mobile-assisted language learning applications and digital platforms enable learners to engage with language beyond the classroom, supporting both grammatical and pragmatic development through repeated and contextualized use (Ismayilli & Nuri, 2025). Such approaches align with a linguistic understanding of interlanguage as dynamic and adaptable, highlighting the potential of instructional innovation to support continuous interlanguage restructuring in adult EFL learners.

6. Conclusion

This study has examined interlanguage development in adult EFL learners from a linguistic perspective, drawing exclusively on selected theoretical and empirical literature. The analysis demonstrates that adult interlanguage constitutes a rule-governed, variable, and continuously evolving system shaped by grammatical, pragmatic, and contextual factors. Such findings reinforce the view that learner language reflects systematic developmental processes rather than incomplete or deficient competence. By moving beyond deficit-oriented interpretations of adult second language learning, the paper highlights the enduring relevance of interlanguage theory for both linguistic research and pedagogical practice. Recognizing interlanguage as dynamic and adaptable allows educators to better interpret learner performance and to design instruction that supports ongoing linguistic restructuring. Furthermore, the synthesis underscores the importance of interaction, feedback, and contextualized use in facilitating interlanguage development. Future research may further explore longitudinal patterns of adult interlanguage development, particularly in technology-enhanced learning environments where digital tools and mediated interaction increasingly shape language learning experiences. Such investigations would contribute to a more comprehensive understanding of how instructional contexts and individual learner variables influence the trajectory of interlanguage evolution over time.

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ON DISSYMMETRIES BETWEEN SOURCE TEXT AND TARGET TEXT: NEW PERSPECTIVE

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DOI: 10.5281/zenodo.18004283

Abstract

The topic of the article covers the philosophy of polarity between source and target texts. It is well acknowledged that translation has to attempt to strike a balance between the interests of the original author and those of the translator to construct parallels between the two cultures, the histories that it brings together. Translating refers to a situation that lies midway between the ST and TT. The poles must /meet in the middle at a certain point, which will always be that of the translator. We shall proceed to examine this relation in the purported y = 1/x function, which is an excellent starting point from which to build an understanding of the investigated phenomenon. The evidence of research findings suggests that the relationship between ST and TP in the context of intermediary language is equivalent to the rational function y = 1/x, where y and X correspondingly stand for TT and ST. The concept of a vertical asymptote and a horizontal asymptote states that the translations, even the best ones, would never touch the X-axis, though they would get very close to it.

Keywords: Translation Studies, Source Text and Target Text, Asymmetry in Translation, Intercultural Communication, Colonial Discourse, Equivalence Theory, Philosophy of Language

It is well acknowledged that the conception of translation as an art (act of communication) supports the theory that translation is an interaction between two literatures and their respective cultures in which the source language continuously appears in opposition to the target language. It should be noted that ST-TT in literary hierarchy has never been pushed into the lumber room, and the study of the relationship plays an important role in oiling the wheels of intercultural communication. Source language goes with Target Language like the sun goes with the moon.

One problem in the field of translation studies is the relationship (linkage)between the text termed (worded) the original or the source and the translation of the original (target text).

Before embarking upon a detailed description, it is helpful to make some touches upon the problem of the relationship between the original or source text and the translation of this original from a historical perspective, i.e., looking at this with several views in mind.

There has been a polemic warfare between the source language and the target language. There was a time when the original was perceived as superior to the translation, which was relegated to the position of being merely a copy, albeit in another language. It is the concept of high-status original and today, assumptions about the powerful original are being questioned. "It arose as a result of the invention of printing and the spread of literacy linked to the emergence of the idea of an author as "owner of his or her text". For if a printer or author owned a text, what rights did the translator have? This discrepancy has been encoded into our thinking about the relationship between translation and so-called originals". (S. Bassneet and H. Trivédi, 1992, p. 2).

Tackling the relationship between SL-TL it is also important to remember that the myth of translation as something that diminished the greater original established itself in the period of colonies, when Europe was regarded as the great Original, the starting point, and the colonies were therefore copies, or "translations of Europe, which they were supposed to duplicate. Moreover, being copies, translations were evaluated as less than originals" (S.Bassnett and H. Trivédi p.4).

Thus, the notion of the colony ranks the translation in a lesser (lower) position in the literary hierarchy and the translator as the servant of the source text. Translation has been at the heart of the colonial encounters and has been used in all kinds of ways to establish the superiority of some cultures over others. This is sometimes called *shameful history of translation.*

So how did colonies deal with that dilemma? How might they find a way to assert their own culture? How might they reject the copy or translation without at the same time rejecting everything that might be of value that came from Europe? They began to translate their own literature into European languages. However, today translation studies have challenged the longstanding assumption of translation as inferior to the original-assumption about the powerful original. Thus, present translation studies reassign (reappropriating) the notion of translation as inferior to the original, amplifying the thought that two language systems of evaluation and cultures vary within time and space as worded in Einstein's Theory of Relativity. In this understanding target text is really inferior to the source text; the main philosophy of subordination is embedded in culture, ideology, and history. Octavian Paz looks at this (stands a quite different point) from the opposite view, claiming that translation is the principal means we have of understanding the world we live in. Each text is unique, yet at the same time, it is the translation of another text. No text can be completely original because language itself, in its very essence, is already a translation- first from the nonverbal world and then inverbal, because each sign and each phrase is a translation of another sign, another phrase". (O. Paz, 1992, p. 154). lt is fair to say that there are good seeds of argumentation in the assumption that "no text can be completely original because language itself in its essence is already a translation-from the nonverbal world". The author emphasizes the cognitive function of any text (any language)mirroring the worldview of the given nation on the one

hand, and the worldview of the writer on the other hand; in this context translation is designed in a broader sense. However, as we can see, this a radical view of translation, *labelling it not as a marginal but as a primary activity*. Tejaswini Niranjana goes even further , and suggests that translation both shapes and takes shape.

The dissymmetry tries between SL and TL exists today in the hierarchy of translation. But present interpretation has gained quite a different shape (understanding): "Translation is not a transposition of significance or signs. After the act of translation is over, the original work still remains in its original position. Translation is rather an attempted revitalization of the original in another verbal order and temporal space" (Ganish Devy p.186). In this asymmetrical context, it is the translator's labor to guarantee his/her faithful love to the foreign text as a thinker and a writer. “I had heard another's voice and was convinced that I could never say what he could as were as he did — at most it would have led to an unnecessary repetition" (Hans Erich Nossack p. 228).

The following statement by M. Gill and M.Guzman even sounds as a declaration "The translator is a part of contact between peoples , and since it is rare that two people have the same access to power , the translator is in a privileged position as mediator to make explicit the differences between cultures, expose injustices or contribute to diversity in the world" (M. Gill , M. Guzman pp.121-133).

These ways of thinking emphasize the necessity to take the translator toward the foreign text. Some insights into the mechanisms of these asymmetrical relations might be gained if we examine this relationship in the purported $y = \frac{1}{x}$ function. The primary task I intend to undertake here is the examination of the main contours of source text and target text relationship. The relation between ST and TT is equivalent to rational function $y = \frac{1}{x\prime}$ where y and X - axes correspondingly stand for ST and TT. The figure 1 shows how the function looks.

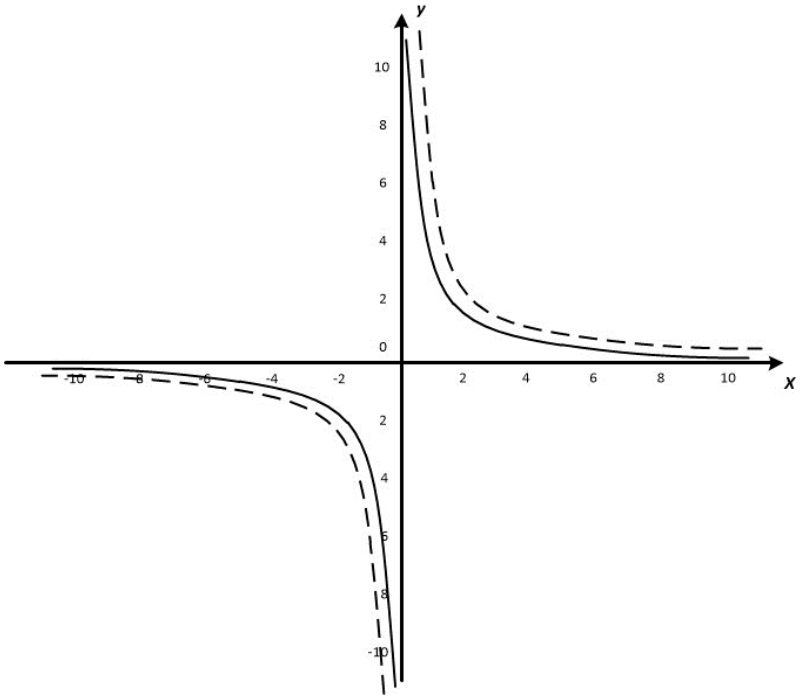

Figure 1. The inverse relation between ST and TT, modeled by y=1/x

As we can see the graph line appears to be heading toward the edge of the diagram but is cut short of that.

Let us look at this function as it leaves the graph at the top and bottom. You should notice the function line approaches, but does not touch the Y-axis. If you graphed the function on a set of x, the function line would still not touch the y-axis, though it would get it very close. This type of behavior about the x-axis is called asymptotic, and in this case, the y-axis would be called a vertical asymptotic of the function, and correspondingly x-axis would be called a horizontal asymptote of the function. As the Y-axis function line stretches out to the left or right, it gets closer and closer to the X-axis, but it never touches it. This is the concept of vertical and horizontal asymptotes. This is our concept of ST and TT. No matter how close, they never break the border between them.

Now, what we may ask is what this hyperbole does in an intermediate context. Does the relation between ST and TT acquire the same contour as in direct translation, or does it obtain another molding in a new time-space dimension? Target text in this new environment operates both as SL2 and TLI. Being distantly located from the main X-axis and closer related to a new lined X-axis, it operates like a mediator in the dialogue between these two poles, whose mission is to bring them closer on the one hand to ST-TT and on the other hand, to bring them as close as possible to the main y-x axis, of the function. Hence, TT/2/ passing in a new format gets a new shaping.

Thus, some scholars sought to relegate TT to a secondary status. Both the ST and TT descend from a common universal, rather than the latter deriving from the former.

The function $y = \frac{1}{x}$ is an excellent starting point from which to build an understanding of ST and TT. Such an approach enabled us to get valuable insights into the nature between SL and TL .

Conclusion

Translation has been at the heart of colonial encounter, and has been used in all kinds to perpetuate the superiority of some cultures over others. But now with increasing awareness of the unequal power of relations involved in the transfer of text across cultures, we are in a position to rethink both the history of translation and its contemporary practice.

As for the relation between ST and TT, it is equivalent to a rational function $y = \frac{1}{x}$.

The translation, even the best one, cannot be melted into the original, architecting a whole entity. In asymmetrical doctrine, they belong to different levels. Though they are opposed to each other, they are two sides of the same coin.

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WOMEN IN THE MIRROR OF SABIR'S SATIRE

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DOI: 10.5281/zenodo.18004334

Abstract

At the beginning of the 20th century, women lived in conditions isolated from public and political life due to illiteracy and fanatical traditions, which created a number of difficulties for their personal lives.

The intellectual elite of Azerbaijan tried to educate the people, explain their rights and duties, and put forward the idea that "until women are free as individuals, the problems of the people will remain unsolvable!" H. Zardabi, A. Aghayev, M. Shahtakhtli, J. Mammadıoğluzadeh, O. F. Nemanzadeh, A. Nazmi, M. A. Sabir, F. Kocharli, M. S. Ordubadi, J. Jabbarli, M. A. Rasulzadeh and others wrote more on this topic. They were able to draw attention to women's problems, not shying away from the attacks of fanatical religious people, criticizing the forced marriage of girls, the treatment of men as slaves, and drawing attention to the need to provide women with an equal education with men.

Each of the artists mentioned above had a unique approach to the issue and artistic generalization. Of them, Mirza Alakbar Sabir's work attracts more attention with its originality in relation to the women's issue.

The article examines Mirza Alakbar Sabir's work from the perspective of women's freedom, and his works, which reflect the motifs of the struggle against women's rights, which has become an important problem of the society of his time, have become the object of analysis.

Keywords: literary environment, freedom, ugliness of the environment, women's theme, examples of art, realism, enlightenment, revolution, etc.

Mirza Alakbar Sabir Tahirzadeh, one of the prominent figures of Azerbaijani literature of the new era, is a great people's poet of Azerbaijan, a patriotic thinker and public figure. He has matured and perfected himself on the pioneering traditions of national literature, classics such as Khagani, Nizami, Fuzuli, Vagif, Akhundov, Seyid Azim, and centuries-old Eastern poetry. Sabir's book of poems known as "Hophopname" is considered a beautiful example of realistic literature and a great monument of national artistic thought. Sabir is the owner of the glory and fame that has been bestowed on a single poet among the Turkic-speaking peoples. As one of the leaders of the "Molla Nasreddin" literary school, he, together with Azerbaijan, had a strong influence on the literary development of many countries of the East, and created a school of poetry distinguished by its originality and great intellectual and aesthetic power.

Sabir came to our literature with such a deep-rooted foundation that we see the yeast of the literary sources he benefited from in each example of art he created. Sabir, who began his creative work in the second half of the 19th century, was able to clarify his poetic convictions at the beginning of the 20th century.

The changes that took place in the life of society at the beginning of the century also affected science, culture and literature. The First Russian Revolution of 1905 laid the foundation for the national awakening not only of the Russian people, but also of the peoples of Transcaucasia. The publication of our democratic press, the magazine “Molla Nasreddin”, and its transformation into a mirror of the life of the people, gave impetus to the creativity of revolutionary-minded artists.

The democratic literary front, which took its leaven from the realism of M. F. Akhundzade, gathered around itself the open-minded, enlightened intellectuals, poets and writers of the time. Among them, undoubtedly, was Mirza Alakbar Sabir. Sabir was a poet even before the revolution. However, it was the poems and immortal works he wrote in 1906-1911 that made him known as a true artist.

“The exposure of tsarism and the exploitative system, the criticism of religious superstition and ignorance, fanaticism and fatalism, the enslavement of women, the education and upbringing of the younger generation, the struggle for the mother tongue, the national press and realistic literature, and the problems of socio-cultural progress also run through the poet’s work with a red line.” (1, p.7)

Sabir, who felt the demands of the changing century, took the themes of his works from real life and tried to create works that caught the pulse of the times. He knew his duty as a poet well and wrote:

I am a poet, because this is my duty, I write poetry,
I write the beautiful things I see, I write explanations.
I write the day bright, your day white, the night dark,
I write the bad bad, the crooked crooked, the straight smooth (2, p.36).

There is no area of life or the current issue of the era that would bypass Sabir’s pen. The hard life of the workers, the ruthless exploitation of workers and peasants, cultural backwardness, religious fanaticism, vulgarity, ignorance, women's rights, etc. issues have always made the great poet think and have become the leitmotif of his literary struggle.

We had already encountered the germs of the struggle against women's rights in the creativity of the enlightened artists of our 19th century literature. The fact that Saadat Khanum ("Rashid Bey and Saadat Khanum") defied tradition and ran away with the young man she loved was an unprecedented event in the 19th century Azerbaijani environment. In the Eastern world, where women were bought and sold as slaves, the

emergence of such a work of art was not only a progressive event, but also a source of inspiration and ideas for artists who came after her.

Mirza Alakbar Sabir also fought against violence against women and women's rights, which were painful aspects of Azerbaijani society at the end of the 19th and beginning of the 20th centuries, and was a supporter of women's participation in public life and joining the public. Sabir saw the difficult living conditions of Azerbaijani women and felt sorry for them. The poet, who understood the benefits of girls' acquiring knowledge and education, rightly shamed those who opposed this idea with his own words in the poem "O heaven, the witness of oppression" and ridiculed their ideas about women. In this poem, told from the lips of those who considered girls' going to school a disgrace and an "oppression" against Islam, the factors that determine the miserable life of Azerbaijani women, the clergy who prepared the ground for their unhappy future, and the environment that made this happen, become the target of the great satirist's criticism and the object of his deadly laughter.

The affirmative pathos of Sabir's satire reflects the growing power of those who embarked on the path of irrevocable struggle for enlightenment in comparison with the forces opposing the enlightenment of society, their influence on all spheres of life, their opportunities to change life, lifestyle, and outlook on life. Here, the increasing penetration of the enlightenment movement into national life becomes the subject of artistic analysis.

In the satire "O heaven, the manifestation of oppression...", the content of the penetration of the "school-nisvan" into social life, reflected in the monologue of the satirical type, proves that the image of the school in the public consciousness is changing. It is felt that in the national environment, the number of those who sympathize with the opening of not only new-type schools, but even "school-nisvans", and those who give impetus to this work is increasing day by day. It is impossible to prevent the carriers of progressive ideas from advancing the school movement and their intentions to expand the school network more and more every day; The socio-cultural movement of the time is breaking the resistance of conservative forces: "... In the Islamic world, in every country, in every city, dinars and dimes should be scattered, schools should be opened, girls should be ready for school, be skilled in science, be excellent in virtue, wear dresses from head to toe, go to school ten by ten, learn dialects and innovations, read and learn wisdom, learn medicine, learn sentences and become literate, learn the habit of writing, be modest in a dog, and be chaste in a bat... oh my, oh my! Oh God!" The transformation of those who fight for a new type of school, which robs the sleep of the satirical type, frightens and worries him, is the determination to mobilize social thought for this movement.

The poet tries to attack the worldview of those who see a woman's duty only in giving birth to children and sweeping the house:

“A girl needs to know: that is, housework, sewing clothes, washing old clothes, combing wool, mending clothes, sweeping the kitchen, blowing out bowls and pans, making meatballs, stuffed cabbage, mat halva, meat bozbashi, or bean stew, and a dakhi tandir lavash. If she doesn't know these, she won't be blamed. However, the most necessary thing for a girl is to know one, two, or three things. If she knows them, she will be enough to command: one is that she should be able to tell her father-in-law and mother-in-law at the house where the bride is going, so that no one dares to say a word to her, and the other is that there is a disagreement between her brother-in-law and her owner, who can do a trick about it, so that in five or three days she can lose so much that has been earned over many years. love can be transformed into enmity; one, and last, and most importantly, one must strive to know the names of the housekeeper, the maid, and the maidservant, how much benefit is there in this matter, one must be careful that if a child cries, or is naughty, and finally his mother says these names, she will comfort her child and remain mentally sound, and she will not be blamed…” (2, p. 82)

In general, the issue of women's liberation was one of the topics that 20th century Azerbaijani literature attached great and serious importance to. It is interesting that this topic excited both realists and romantic artists to the same extent. However, Sabir and his followers had an independent position in the artistic solution of this topic.

The issue of young girls being married off to old men, which had almost become the scourge of the century, infuriated Sabir even more, and he sharply lashed out at the society that treated women as objects:

Wow, this is not human,
This is not a way of conforming to a certain image,
If you love God, this is not a husband,
Don't let him go, he's a wild boar,

He's a bad man By explaining the rights of his compatriots who were poor, excluded from school, plunged into the whirlpool of ignorance, and deprived of their rights, the poet first served the independence of the Azerbaijani people to which he belonged, and then of other peoples with the same fate. His name deserves to be listed in the same row as the outstanding artists in world literature who fought for human rights and opposed slavery. Mirza Alakbar Sabir's satire "What would you do with people with a heart of stone, O God", published in the magazine "Molla Nasreddin" on January 6, 1908, deeply analyzes the fate of humanity in a broad sense. Here, the poet expressed his support for the oppressed, whose tears were like a sea, and his opposition to oppressors and oppression and injustice in general, with great civic courage:

Who would not remain honest and pure in a time,
I don't know what would you do with such times, O God?!

The tears of the oppressed would become a sea,
What would you do with the seas and oceans, O God?!

The lords would see the benefits of the garden and the crops,

What would you do with the farmers to plant the seeds, O God?!

Ignorance would rule the whole world, –

What would you do with the knowledge on the tongue, O God?! (2, p.145)

The questions raised in the satire sound relevant in Azerbaijan, as well as in the Turkic-Muslim world and other countries, and seek a full, fair answer. Expressing his attitude to the unwritten laws of society, the poet does not remain indifferent to the unfortunate fate of the Azerbaijani woman:

Our merchants will be slaves to Sonyas,

What would you do with the unfortunate Tukezbans, God? (2, p.146)

– he criticized and protested against the positive attitude of our men towards Russian women, not towards women of their own nation. In social reality, he tried to change the way of looking at life by reminding the hero, who is devoid of national thought and is ready to sacrifice his millions for the sake of Annas, Lizas, and Sonyas, of aesthetic thought, Zalkhalar, Fatma - Tukezbans.

“The life reflected in Sabir's satirical mirror may be small in scale. However, we should not forget that the picture presented by the poet with the smallest details and strokes is memorable and significant as a necessary aspect of life” (3, p.27)

In Sabir's work, science and education issues are very accurately written in unity with the problems of upbringing and morality, which is a very realistic approach to existing problems. “It is no coincidence that Sabir, as an intellectual who actively responded to the processes taking place in society, wrote works promoting science, education, enlightenment and culture, and also became one of the creators of children's literature with his poems for children "A Contribution to School Children", "A Contribution to School Students", "Incitement to School", "Incitement to Science", "The East of School", etc. In these poems, Sabir showed the exceptional role of school in the formation of children as true citizens in society, called them to school, science, education and brought to mind the need to be diligent, knowledgeable and moral. Just as the advice of a father, mother and teacher is valuable and important for every child, Sabir's poems are equally instructive and irreplaceable.” (4, p.4)

At the beginning of the 20th century, the problem of the freedom of Azerbaijani women was first raised in the "Shargi-Rus" newspaper, which began publication in Tbilisi on March 30, 1903. Its founder, a prominent representative of Azerbaijani enlightenment, Mahammad agha Shahtakhtli, wrote and published articles on women's freedom in the Muslim world. His writings on this topic were mainly devoted to problems that limited women's freedom and isolated them from the surrounding world and public life.

This is one of the signs confirming the transformation of Azerbaijani women into a serious social force at the beginning of the 20th century. The increasing intensification of speeches by women authors here and on the pages of other press organizations, their more confident expression of their positions in the exchange of views with authors of different positions, etc. once again showed that the struggle of the Azerbaijani press for women's freedom at the beginning of the 20th century was not in vain.

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NOTES ON THE LIFE AND WORK OF MARK TWAIN

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Abstract

Mark Twain is one of the most important figures in American literature, and his work occupies an indispensable place in the literature of his people. Twain depicted American society, especially the life of people living on the banks of the Mississippi River, in a realistic and satirical style in the late 19th and early 20th centuries. His works are also considered a turning point in the development of American literature.

Twain played an important role in the development of realism in American literature. The accurate and detailed description of life in his works, the use of regional dialogues, and the realistic reflection of everyday life served as a model for other writers. In particular, the work “Huckleberry Finn” is an important example that realistically presents the social and cultural characteristics of American society.

Twain’s work plays the role of social and moral criticism in the literature of his people. His works present slavery, racism, discrimination, and the double standards of society in an ironic and satirical manner. This has had a significant impact not only on literature, but also on the formation of social thought.

Keywords: Mark Twain, American literature, realism, social life, writer, journalist, adventure genre, satire, humor, criticism, etc.

Mark Twain (Samuel Langhorne Clemens) is one of the most important figures in American literature, and his work occupies an indispensable place in the literature of his people. Twain depicted American society in the late 19th and early 20th centuries, especially the life of people living on the banks of the Mississippi River, in a realistic and satirical style. His works are also considered a turning point in the development of American literature.

Twain made revolutionary changes in American children's and young adult literature. In the works of Tom Sawyer and Huckleberry Finn, social and moral messages are conveyed to the reader through the adventures and freedom of children, and their relationships with society. This approach brought a new style and perspective to American children's literature.

Twain's works play a role in preserving and at the same time criticizing the cultural identity of his people. His work, reflecting the regional and national characteristics of American society, remains a historical and cultural value for future generations.

Mark Twain played an innovative role in the development of realism in American literature, in presenting social criticism and moral messages, as well as in children's and young adult literature. His works, masterfully reflecting the life, culture, and social problems of his people, played an indispensable role in the formation and enrichment of American literature (1, p.27).

Samuel Langhorne Clemens, better known as Mark Twain, was an American writer who lived in the late 19th and early 20th centuries. Twain's works reflect American life, especially the social and cultural life of the Mississippi River region. He masterfully combined the themes of childhood and youth, the injustices of society, and the ironic aspects of human nature, leaving an unforgettable legacy to world literature.

Twain's work is distinguished by its realistic depictions and satirical style. His works are relevant not only in American literature, but also for the world reader. This article will analyze Twain's life, main works, themes, artistic style, influence, and contemporary critical opinions.

Mark Twain was born in 1835 in Florida, Missouri. His youth was spent as a riverboat captain on the Mississippi River, and these experiences later formed the basis of realistic depictions in his works.

Twain, who began his journalistic career at a young age, both criticized society and humorously reflected people's daily lives in his writings. His travels (Europe, the Middle East) led him to gain a broad perspective (2, p.43).

Among his major works are The Adventures of Tom Sawyer (1876), Adventures of Huckleberry Finn (1884), The Prince and the Pauper (1881), A Connecticut Yankee in King Arthur's Court (1889). These works directly reflect Twain's life and experience.

The theme of childhood is at the forefront in Twain's works. In the works of Tom Sawyer and Huckleberry Finn, the freedom, adventures, and conflict with society are the main themes. The mistakes of society are shown through the eyes of children.

Example: In the work "Huckleberry Finn", Huck's journey is not only an adventure, but also a symbol of social and moral dilemmas. Twain criticized the injustices and double standards in American society through satire.

Twain's ironic style is the most important element of his works. The absurdity of human behavior and the paradoxes of society are reflected through satire. Twain prefers regional dialogues in his works, which provide the reader with an accurate cultural and social context. For example, in Huckleberry Finn, the style of speech of different social groups is shown.

Twain is known for his realistic descriptions. Detailed descriptions of the Mississippi River, villages and cities add depth to the works. Satire, on the other hand, shows the mistakes of society through humor.

The works of Mark Twain (Samuel Langhorne Clemens) are distinguished by a masterful combination of realism, satire, irony and adventure genres. In his

works, an accurate and realistic depiction of life is at the forefront. He realistically presents the banks of the Mississippi River, rural and urban life, and the lifestyle of different social classes. This realism creates a vivid description of events for the reader and increases the credibility of the characters in the works. For example, the description of river voyages and local communities in Huckleberry Finn is a clear example of realism (3, p.24).

The most characteristic feature of Twain's creative style is the elements of satire and irony. He shows the mistakes of society and the absurdity of human behavior with humor and irony. This approach both entertains and makes the reader think. Twain's satirical style is especially important in criticizing the double standards of society and issues of racism.

Twain attaches great importance to regional dialogues and local speech in his works. This more accurately shows the individual traits and social positions of the characters in his works. Through dialogues, the reader has the opportunity to understand the social status, cultural affiliation, and character traits of each character.

The children's perspective is combined with a satirical depiction of society. The adventure genre makes social criticism more accessible. Mark Twain's work occupies a special place in the development of the adventure genre in American literature. In his works, adventure is not only for entertainment purposes, but also as a means of conveying social, moral and cultural messages. Twain skillfully combines the social problems of society, various aspects of human nature and moral dilemmas from the perspective of children and young people.

The most famous works of M. Twain — The Adventures of Tom Sawyer and Adventures of Huckleberry Finn — are the most striking examples of the adventure genre. In these works, children's freedom, participation in unusual events and opposition to the rules of society are the main motifs. Adventure here is both an important structural element of the story and a means of conveying social messages (4).

The adventure genre is also used in Twain's works to show the shortcomings of society. For example, Huck's journey along the Mississippi River in Huckleberry Finn is not only an adventure story, but also a criticism of social problems such as slavery and racism. Through adventure, the reader is entertained, but at the same time thinks about the injustice of society and the paradoxes of human behavior.

Twain's adventure works are more convincing when combined with realism. Accurate descriptions of the Mississippi River, villages and cities create a vivid impression of events in the reader. The adventure genre, combined with realistic descriptions and satire, gives Twain's works both an entertaining and enlightening quality.

Twain's adventure works influenced the formation of the adventure genre written for children and young people in world literature. His works became an example for other writers in terms of style and subject matter, enriching the adventure genre with social and moral messages.

In Mark Twain's work, the adventure genre is of great importance not only as an element of entertainment, but also as a means of transmitting social, cultural and moral messages. Adventure and realism, combined with satire and social criticism, make Twain's works unforgettable in both American and world literature.

Twain's works had a great influence on the development of realism in American literature. His style has been imitated in world literature and loved by readers. Twain's role in children's and young adult literature is particularly important because his works convey moral and social messages through adventure stories.

Mark Twain (Samuel Langhorne Clemens) was one of the most important figures in American literature in the late 19th and early 20th centuries. His work has had a significant impact not only on American literature, but also on world literature. The importance of Twain's works can be noted in several main aspects:

Works such as "Tom Sawyer" and "Huckleberry Finn" presented the adventure genre not only as a means of entertainment, but also as a platform for teaching social and moral issues. This pioneered the combination of realism and social messages in children's and young adult literature.

In his works, Twain gave an accurate description of real life, different classes of American society, and regional characteristics. He presented topics such as slavery, racism, and social injustice in an ironic and satirical style, making readers think (5, p.49).

Twain's style, by showing the wrongs of society with humor and irony, offers the reader both an entertaining and thought-provoking experience. This approach influenced the development of social realism and satire in world literature.

Twain's works have been translated into various languages and have reached a global readership, and have become a model for other writers in terms of style and subject matter. His method of dialogue and character description, especially in the realism and adventure genres, has led to the formation of new approaches.

Twain's works are important not only in the field of literature, but also for culture and education. The social messages and descriptions of human nature in his works contribute to the development of readers' ethical and moral thoughts.

Mark Twain's work played an important role in the combination of realism, satire, and social criticism in American and world literature. His works are significant not only for their ability to entertain, but also for their ability to present profound social and cultural messages. For this reason, Twain's legacy will be valued and read for a long time, both from a literary and cultural perspective.

Modern literary criticism emphasizes Twain's intertextual and cultural significance. The translation of Twain's works into various languages has increased his global importance.

Mark Twain is one of the strongest figures not only in American literature, but also in world literature. His works, presenting a unique combination of realism and satire, both entertained readers and made them think about social and moral issues of society.

One of the main aspects of Twain's influence on world literature is the new approach he brought to children's and young adult literature. The works "Tom Sawyer" and "Huckleberry Finn" made the adventure genre not only a means of entertainment, but also a platform for social criticism and in-depth analysis of human behavior. This approach had a wide impact on works written for children and young adults, especially in European and Asian literature. Writers began to create stories that were both entertaining and enlightening, taking Twain's style of combining adventure and realism as an example.

Twain's influence on world literature was also manifested in the style of social and political criticism. His works present racism, discrimination, and the paradoxes of society in an ironic and satirical manner. This approach influenced the development of social realism and satire styles in Europe and Latin America, providing writers with a model for criticizing social problems through literature. For example, many 20th-century European writers, especially the English and German realists, took inspiration from Twain's style of irony and social criticism (5, p. 53).

In addition, the regional dialogues and depictions of local cultures in Twain's works brought new perspectives to world literature. He created individual lines with each character's speech style and social context, which led to a more realistic approach to dialogue and character development in writers from other countries.

Mark Twain's influence is not limited to literature; his works have also found wide resonance in world culture. Films, theater performances, and animations have brought Twain's works to a global audience, passing on his ironic style and social criticism to new generations. In this regard, Twain's legacy has had a significant impact not only on the stylistic development of world literature, but also on the social and cultural aspects of literary thought.

Consequently, Mark Twain's work played an important role in the combination of realism, satire and adventure genres in world literature. His works, in addition to creating opportunities for social criticism for writers, created conditions for the formation of new styles in works written for children and young people in literature. Thus, Twain had a deep and lasting influence not only on American literature, but also on the global literary space.

Mark Twain's work played an indispensable role in the development of American literature. The themes of childhood, adventure, social criticism and irony are skillfully combined in his works. Twain's legacy is still relevant for modern literary and cultural studies.

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MODERN PEDAGOGİCAL TECHNOLOGİES İN THE FORMATİON OF SPEECH SKİLLS İN FOREİGN LANGUAGE TEACHİNG

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XARİCİ DİLİN TƏDRİSİNDƏ NİTQ BACARIQLARININ FORMALAŞMASINDA MÜASİR PEDAQOJİ TEXNOLOGİYALAR

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Abstract

The application of modern pedagogical technologies in the digital era has changed the methodology of foreign language education and offered innovative tools and resources to improve teaching and learning. This article examines the role of modern pedagogical technologies in foreign language teaching, explores the benefits of technology-enhanced learning, explores new trends in digital language learning, and discusses practical strategies for integrating technology into language teaching. By using the potential of modern pedagogical technologies, teachers can create dynamic and interactive language learning environments that promote active learning, collaboration, and the improvement of language skills. The growing demand for foreign language skills in the global world makes the effective formation of speech skills relevant. Since traditional teaching methods are based on the passive form of learning of the student, the application of modern pedagogical technologies has become a necessity. Interactive, communicative and student-oriented methods create conditions for the complex development of speech activity - listening, speaking, reading and writing. The application of modern pedagogical technologies makes the teaching of a foreign language student-centered, interactive and practical. Through these technologies, speech skills are formed faster, more effectively and continuously. The student masters language knowledge not only at the grammatical level, but also in the process of real communication.

Xülasə

Rəqəmsal dövrdə müasir pedaqoji texnologiyaların tətbiqi xarici dil təhsil metodikasını dəyişdirərək tədris və öyrənməni təkmilləşdirmək üçün innovativ alətlər və resurslar təklif etmişdir. Bu məqalədə xarici dil tədrisində müasir pedaqoji texnologiyaların rolu araşdırılır, texnologiya ilə təkmilləşdirilmiş öyrənmənin faydaları araşdırılır, rəqəmsal dil öyrənməsində yeni tendensiyalar araşdırılır və texnologiyanın dil tədrisinə inteqrasiyası üçün praktik strategiyalar müzakirə olunur. Müasir pedaqoji texnologiyaların potensialından istifadə etməklə müəllimlər fəal tədris, əməkdaşlıq və dil biliklərinin artırılmasını təşviq edən dinamik və interaktiv dil öyrənmə mühitləri yarada bilərlər. Qlobal dünyada xarici dil biliklərinə artan tələbat nitq bacarıqlarının effektiv formalaşdırılmasını aktuallaşdırır. Ənənəvi tədris metodları şagirdin passiv öyrənmə formasına əsaslandığından müasir pedaqoji texnologiyaların tətbiqi zərurətə çevrilmişdir. İnteraktiv, kommunikativ və tələbəyönlü metodlar nitq fəaliyyətinin – dinləmə, danışma, oxuma və yazmanın – kompleks inkişafına şərait yaradır. Müasir pedaqoji texnologiyaların tətbiqi xarici dilin tədrisini şagird mərkəzli, interaktiv və praktik edir. Bu texnologiyalar vasitəsilə nitq bacarıqları daha sürətli, effektli və davamlı formalaşır. Şagird dil biliyini yalnız qrammatika səviyyəsində deyil, real kommunikasiya prosesində mənimsəyir.

Keywords: teaching, grammar, speech, skills, communicative, methods
Açar sözlər: tədris, qrammatika, nitq, bacarıqlar, kommunikativ, metodlar

Məqalədə xarici dilin tədrisində nitq bacarıqlarının inkişafına təsir edən müasir pedaqoji texnologiyaların rolu araşdırılır. Rəqəmsal vasitələr, kommunikativ təlim metodu, tapşırıq yönlü yanaşma, CLIL, interaktiv üsullar və layihə əsaslı təlimin nitq fəaliyyətini gücləndirməsi elmi-nəzəri və praktik aspektlərdə izah olunur. Tədqiqat göstərir ki, müasir pedaqoji texnologiyalar şagirdin aktivliyini artırır, motivasiyanı yüksəldir və real ünsiyyət şəraiti yaratmaqla nitq bacarıqlarının daha səmərəli formalaşmasını təmin edir.

Giriş. Qloballaşma və informasiya-kommunikasiya texnologiyalarının sürətli inkişafı xarici dilin insan fəaliyyətinin hər sahəsində əhəmiyyətini artırmışdır. Bunun nəticəsi olaraq, dil tədrisi yalnız qrammatik biliklərin mənimsənilməsi ilə məhdudlaşmır, danışıq, dinləyib-anlama, oxu və yazı kimi nitq bacarıqlarının kompleks şəkildə inkişafına ehtiyac yaranır. Ənənəvi metodlar bu ehtiyacı tam

ödəmədiyi üçün son illərdə müasir pedaqoji texnologiyaların xarici dilin tədrisinə inteqrasiyası geniş vüsət almışdır. Bu texnologiyalar şagirdin müstəqil fəaliyyətini, yaradıcı düşüncəsini və real dil mühitində ünsiyyət bacarığını gücləndirir.

1. Xarici dil tədrisində nitq bacarıqları

1.1. Dinləyib-anlama

Dinləmə nitq fəaliyyətinin əsas komponentidir və şagirdin səsli mətnləri anlamasını təmin edir. Müasir pedaqoji texnologiyalar — podkastlar, video dərslər, interaktiv audio tapşırıqlar — dinləmə bacarığını artırır.

1.2. Danışıq

Danışıq bacarığı dil öyrənmənin mərkəzində dayanır. Yüksək kommunikativ mühit yaratmaq üçün dialoqlar, rol oyunları, debatlar, səsli mesaj mübadiləsi və onlayn platformalar geniş istifadə olunur.

1.3. Oxu və yazı

Müasir yanaşmalarda oxu və yazı bacarıqlarının inkişafı üçün rəqəmsal mətnlər, elektron kitablar, onlayn yazı platformaları, QR-kodlu tapşırıqlar tətbiq edilir.

2. Xarici dilin tədrisində müasir pedaqoji texnologiyalar

2.1. Kommunikativ Təlim Metodu (CLT)

Kommunikativ yanaşma şagirdlərin dil vasitəsilə real ünsiyyət qurmasına şərait yaradır. Bu metodda interaktiv fəaliyyətlərə — “role-play”, “information gap”, dialoqlar, situativ danışıqlar — üstünlük verilir. CLT nitq bacarıqlarının təbii yolla formalaşmasını təmin edir.

2.2. Tapşırıq yönlü təlim (Task-Based Learning)

Bu texnologiya tapşırıqların yerinə yetirilməsi zamanı dil strukturunun praktik istifadəsinə əsaslanır. Problem həlli, qrup işi, layihə hazırlığı kimi fəaliyyətlərdə şagirdlər dilə aktiv müraciət edir, danışıq və dinləmə bacarıqları inkişaf edir.

2.3. CLIL (Content and Language Integrated Learning)

CLIL modeli fənn məzmununun xarici dildə öyrədilməsi prinsipinə əsaslanır. Bu modeldə dil vasitə rolunu oynayır və şagird həm fənni, həm də dili eyni vaxtda mənimsəyir. CLIL danışıq bacarığını gücləndirən ən effektiv texnologiyalardan hesab olunur, çünki şagird real bilik mühitində ünsiyyətə daxil olur.

2.4. İnteraktiv təlim üsulları

“Akvarium”, “Debat”, “Beyin həmləsi”, “Karusel”, “Think-Pair-Share” kimi metodlar şagirdlərin fikirlərini sərbəst ifadə etməsinə imkan yaradır. İnteraktiv metodlar kommunikativ yanaşmanın əsasını təşkil edir və nitq fəallığını artırır.

2.5. Rəqəmsal texnologiyalar

Rəqəmsal vasitələr nitq bacarıqlarının formalaşmasında mühüm yer tutur.

Məşhur alətlər:

1. Kahoot , Quizlet — söz ehtiyatının artırılması üçün
2. Duolingo , Memrise — gündəlik danışıq praktikası
3. Padlet , Jamboard — qrup müzakirələri və projekt işləri
4. YouTube , podkastlar — dinləmə materiallarının zənginləşdirilməsi

Rəqəmsal yanaşmalar şagirdin motivasiyasını artırır, fərdiləşdirilmiş təlim təmin edir və danışıq bacarıqlarının inkişafı üçün real kommunikasiya imkanları yaradır.

2.6. Layihə əsaslı təlim (PBL)

Layihə işləri şagirdləri tədqiqat aparmağa, məlumat toplamağa və onu təqdim etməyə vadar edir. Poster, video, təqdimat, interaktiv esse hazırlamaq nitq bacarıqlarının təbii formalaşmasına kömək edir.

3. Nitq bacarıqlarının inkişafı üçün texnologiyaların tətbiq nümunələri

3.1. Danışıq

“Role-play” — restoran, hava limanı, mehmanxana kimi situasiyalarda dialoqlar

Səsli video jurnallar (oral journals)

“Speed speaking” — qısa vaxtda fikir ifadəsi

3.2. Dinləmə

Kriminal hekayə podkastları ilə mətn sonunu təxmin etmək

Video fraqmentlərə əsaslanan sual-cavab

Sürətli dinləmə ilə əsas ideyanın müəyyənləşdirilməsi

3.3. Yazı

Onlayn redaktorlarla esse yazmaq

Kooperativ yazı (iki şagird bir mətn hazırlayır)

Cümlə modellərindən istifadə

3.4. Oxu

Skimming və scanning strategiyaları

QR-kodlu mətnlərlə iş

Məlumatı tap və təqdim et tapşırıqları

Nəticə. Araşdırmalar göstərir ki, müasir pedaqoji texnologiyalar xarici dilin tədrisində nitq bacarıqlarının inkişafı üçün mühüm əhəmiyyət kəsb edir. İnteraktiv, kommunikativ və rəqəmsal yanaşmalar şagirdin dil mühitinə daxil olmasını təmin edir, onun yaradıcı və tənqidi düşüncəsini inkişaf etdirir və real ünsiyyət bacarığının formalaşmasına şərait yaradır. Bu texnologiyalar təlim prosesini müasir tələblərə uyğunlaşdırır və dil öyrənməsini daha dinamik, səmərəli və motivasiyaedici edir.

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BEYOND LINGUISTIC COMPETENCE: INTEGRATING CRITICAL THINKING SKILLS INTO FOREIGN LANGUAGE EDUCATION

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Abstract

In the contemporary landscape of English as a Foreign Language (EFL) education, the primary objective has shifted from mere linguistic accuracy to the development of intercultural communicative competence and higher-order thinking skills. This paper explores the intrinsic relationship between language acquisition and critical thinking (CT), arguing that foreign language classrooms are unique environments for fostering cognitive flexibility. Despite the theoretical consensus on the importance of CT, empirical evidence suggests a gap between policy and practice, often due to a focus on rote memorization and grammatical form over meaning construction. This study reviews recent pedagogical frameworks that integrate CT into L2 instruction, examining strategies such as problem-based learning, Socratic questioning, and text analysis. The findings suggest that when language learners are encouraged to analyze, evaluate, and synthesize information in the target language, they not only improve their cognitive abilities but also achieve deeper linguistic proficiency. The paper concludes that for EFL education to remain relevant in a globalized world, curricula must explicitly embed critical thinking objectives alongside linguistic goals.

Keywords: Critical Thinking, EFL, Applied Linguistics, Transformative Pedagogy, Higher-Order Thinking Skills.

1. Introduction

For decades, foreign language education was dominated by the pursuit of native-like fluency, characterized largely by grammatical precision and lexical breadth. However, the demands of the 21st-century information age have necessitated a paradigm shift. Today, language is increasingly viewed not just as a code to be mastered, but as a vehicle for complex thought and intercultural inquiry. Within this context, Critical Thinking (CT) has emerged as a pivotal component of the curriculum. Defined by Paul and Elder as "self-directed, self-disciplined, self-monitored, and self-corrective thinking," CT involves the ability to analyze information objectively and make reasoned judgments. [5]

In the context of Foreign Language (FL) education, the integration of CT presents a dual challenge and opportunity. On one hand, the cognitive load required to process a second language can inhibit higher-order thinking; learners often struggle to express complex thoughts due to limited proficiency. On the other hand, the very process of learning a new language requires a suspension of native norms and an analysis of new patterns, which is inherently a critical exercise. This paper argues that CT is not an optional "add-on" to language teaching but a fundamental driver of deep language acquisition. By examining current methodologies and recent academic literature, this article aims to provide a theoretical and practical framework for moving beyond surface-level linguistic competence toward a more intellectually rigorous language pedagogy.

2. Pedagogical Frameworks and Implementation Strategies

2.1 The Symbiosis of Language and Thought

The relationship between language and thought has long been debated, from the Sapir-Whorf hypothesis to Vygotsky's sociocultural theory. In modern applied linguistics, it is widely accepted that language development and cognitive development are reciprocal. Recent studies indicate that integrating CT into the curriculum does not hinder language progress; rather, it enhances it. When students are engaged in activities that require analysis—such as distinguishing fact from opinion in a target language text—they process the linguistic input at a deeper level than they would through mechanical drilling. [3]

By design, integrating critical thinking into language instruction cultivates metalinguistic awareness: learners reflect on how language structures shape meaning and how rhetorical choices influence persuasion.[5] Tasks that require hypothesis testing, comparing contrasting texts, or constructing evidence-based claims push students to manipulate language with purpose, deepening lexical networks and grammatical control. Scaffolding—through sentence frames, guided questioning, and teacher modeling—enables learners to express complex reasoning before fluency is reached, and collaborative activities promote dialogic interaction where ideas are negotiated and refined. Moreover, assessment should value reasoning processes as much as final products: rubrics that reward justification, source evaluation, and clarity of argument signal that language learning includes intellectual

work. When instructors explicitly teach thinking strategies (e.g., identifying assumptions, weighing evidence, considering counterarguments) within language-focused tasks, learners transfer these skills across contexts, improving communicative competence and autonomy. Viewing language as a vehicle for thought empowers students to use L2 for inquiry, not replication[4].

2.2 Strategies for the EFL Classroom

To effectively foster critical thinking, educators must move beyond the "banking model" of education, where teachers deposit knowledge into passive students, toward a problem-posing methodology.

• **Problem-Based Learning (PBL):** PBL places students in active roles where they must solve open-ended problems using the target language. For instance, instead of simply learning vocabulary related to "environment," students might be tasked with drafting a policy proposal for local waste management. This requires them to research, synthesize arguments, and defend their positions in the target language (L2).

• **Socratic Questioning and Debate:** Teachers can elevate classroom discourse by asking questions that require more than memory recall. Shifting from "What?" and "When?" questions to "Why?" and "What if?" prompts forces learners to generate complex output. Structured debates are particularly effective, as they require students to anticipate counter-arguments, a core skill in critical analysis. [2]

• **Critical Reading and Media Literacy:** In an era of digital misinformation, the EFL classroom is an ideal setting to teach media literacy. Analyzing news articles from different cultural perspectives allows students to identify bias, tone, and underlying assumptions. This "critical literacy" approach treats the text not as an object to be memorized, but as a social construct to be interrogated. [3]

2.3 Challenges in Implementation

Despite the clear benefits, implementing CT in the EFL classroom is fraught with challenges. One significant barrier is the proficiency threshold; teachers often underestimate students' ability to think critically because of their inability to articulate thoughts fluently in L2. Furthermore, cultural perceptions of the teacher's authority can hinder the questioning spirit necessary for CT. In some educational cultures, questioning a text or a teacher is seen as disrespectful, requiring a sensitive, culturally responsive pedagogical approach to encourage independent thought. [4]

3. Conclusion

The integration of Critical Thinking into foreign language education represents a necessary evolution in the field of applied linguistics. As this paper has demonstrated, the separation of "language learning" from "thinking skills" is a false dichotomy. [1] The cognitive processes involved in decoding, analyzing, and producing a foreign language are intrinsically linked to critical inquiry.

By adopting strategies such as Problem-Based Learning and critical discourse analysis, educators can empower students to become not just fluent speakers, but competent intercultural thinkers. [2] The literature reviewed suggests that while challenges exist—particularly regarding student proficiency levels and cultural expectations—the long-term benefits of a CT-integrated curriculum are undeniable. Future research should focus on longitudinal studies that measure the impact of CT instruction on specific linguistic domains, such as writing coherence and pragmatic competence, to further solidify this pedagogical direction.

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PHYSICAL SCIENCES

ELECTRICAL AND OPTICAL PROPERTIES OF SINGLE-WALLED CARBON NANOTUBE

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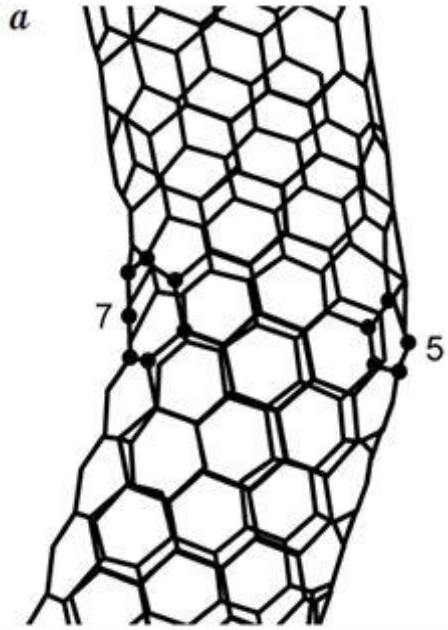
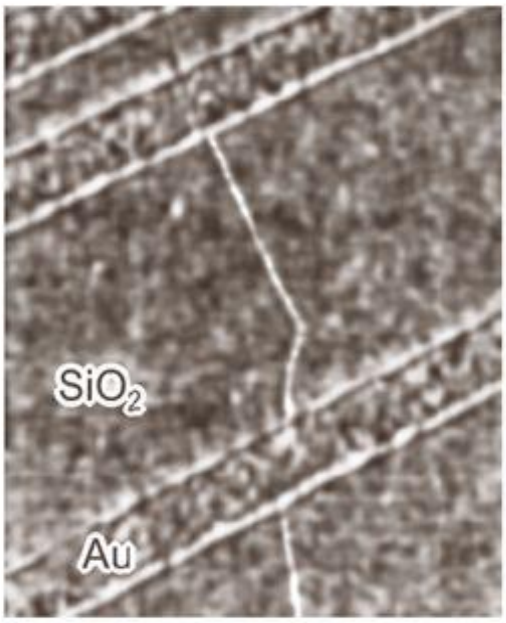
Abstract

Metallic nanotubes, owing to their high transparency, can exhibit excellent electrical conductivity, enabling their use as nanowires or transparent electrodes in various fields of nanoelectronics and photovoltaics. Semiconductor nanotubes, with their high charge-carrier mobility, are promising materials for transistor applications. The electronic properties of single-walled carbon nanotubes (SWCNTs) can be tuned by doping with electron-donor or electron-acceptor compounds. This work presents the results of separating SWCNTs according to their conductivity type. The resulting semiconductor and metallic fractions were characterized by optical spectroscopy. When the fractions were filled with copper chloride, an electron-accepting compound, changes in their optical properties were observed. The article also employs the aqueous polymer two-phase (ATPS) separation method for sorting SWCNTs by conductivity type.

Keywords: carbon, nanotubes, semiconductor, electric.

Single-walled carbon nanotubes (SWCNTs) are an allotrope of carbon consisting of a graphene sheet rolled into a cylindrical shape. They have unique electrical, mechanical, and optical properties, making them useful in many technological applications — nanoelectronics, optoelectronics, sensors, and energy storage systems. Nanotubes possess several properties essential for electronics. They may exhibit either semiconducting or metallic conductivity. The magnitude and type of conductivity in semiconductor nanotubes can be modified through external influences. The electrical properties of nanotubes — high electrical conductivity and good thermal conductivity — make them promising materials for nanoelectronics. The dependence of electrical properties on structure enables the formation of pn-junctions and heterojunctions within an individual nanotube. If defects in the form of pentagon and heptagon cells located at opposite ends of the diameter are introduced into a nanotube composed of hexagonal cells, the nanotube will bend. An AFM image of the bent nanotube in contact with a quartz substrate and gold electrodes is shown in the figure. The current–voltage characteristics of the bent nanotube are nonlinear. The upper straight section (before bending) exhibits metallic conductivity; its current–voltage characteristic is linear. The conductivity of the lower and upper sections differs due to the different orientation of lattice cells relative to the nanotube axis. It is possible to obtain nanotubes containing both semiconducting and metallic sections. Such a nanotube functions as a rectifying (Schottky) diode. The AFM image of the bent nanotube on a quartz substrate (b) and the current–voltage characteristic arising at the bend (volt-ampere characteristic) are shown.





The use of SWCNT-based media in laser physics requires a detailed understanding of their optical properties. Conductivity-sorted SWCNTs enable the advantages of both semiconducting and metallic fractions to be fully utilized. Sorting SWCNTs allows tuning of their operational spectral range, which, when matched to the laser wavelength, significantly enhances quantum efficiency. Furthermore, the narrower distribution of properties in sorted SWCNTs provides superior performance compared to unsorted mixtures. In laser physics, semiconductor nanotubes used as saturable absorbers yield greater modulation depth than mixtures of SWCNTs. Conversely, pure metallic fractions can substantially improve the performance of saturable absorbers. In photoluminescence studies, the presence of metallic SWCNTs in mixed samples increases nonradiative relaxation of photoexcited states, reducing the quantum yield of semiconductor nanotubes. This study demonstrates the separation of SWCNTs by conductivity type and examines the optical properties of the resulting fractions. The aqueous polymer two-phase separation method—based on spontaneous partitioning of two immiscible polymers, polyethylene glycol (PEG) and dextran (Dx)—was used. The PEG-rich upper phase is more hydrophobic than the dextran-rich lower phase, and the hydrophobicity contrast between the phases can be tuned by adjusting polymer concentrations.

Electrophysical Properties of SWCNTs

Depending on their chirality indices, SWCNTs may exhibit either semiconducting or metallic conductivity. Their one-dimensional structure gives rise to unique physical phenomena such as Coulomb blockade and charge transport described by the Luttinger-liquid model. Metallic nanotubes, with their high transparency, can serve as nanowires or transparent electrodes in nanoelectronic and photovoltaic devices. Semiconductor nanotubes, due to their high charge-carrier mobility, are promising for transistor fabrication. The electronic properties of SWCNTs can be modified through doping with electron-donor or electron-acceptor species.

In single-walled armchair nanotubes, as in graphene, the valence and conduction bands intersect at a single point at the Fermi level. In this case, two conductive channels arise: one when the cutting line intersects the K point of the graphene Brillouin zone, and another when it intersects the K′ point. Thus, an ideal armchair nanotube exhibits metallic conductivity.

$$2G_0 = \frac{4e^2}{h'} \quad (1)$$

where G_0 = 75 μS is the conductance quantum including spin degeneracy. By shifting the Fermi level, the conductivity of nanotubes can be increased as the number of conductive channels grows. Experimental studies of SWCNT conductivity [5] showed measured conductance values to be very close to theoretical predictions. This is noteworthy because defects in nanotubes would normally be expected to scatter electrons. In practice, however, scattering of charge carriers near the Fermi level is strongly [1] suppressed. Because electron states are distributed around the nanotube circumference, the influence of a defect is effectively averaged over the entire perimeter. Consequently, the larger the nanotube diameter, the less defects affect its conductivity. As a result, ballistic transport can occur in SWCNTs.

Conclusion

The article investigates field emission in conductivity-sorted single-walled carbon nanotubes. For semiconductor nanotubes, nonlinearity in current–voltage characteristics is observed due to high electrical resistance. Separating SWCNTs by conductivity allows tuning their operational spectral range, which, when matched with laser wavelength, significantly increases quantum efficiency. Furthermore, using sorted SWCNTs is advantageous due to the narrower distribution of their properties. In laser physics, using semiconductor nanotubes as saturable absorbers allows achieving greater modulation depth compared to using mixtures of SWCNTs. On the other hand, the pure metallic fraction can significantly improve the performance of saturable absorbers.

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SOCIAL SCIENCIES

THE ROLE OF SOCIAL WORKERS IN PROMOTING SELF-FULFILLMENT AMONG OLDER PEOPLE

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DOI: 10.5281/zenodo.18004454

Abstract
The aging population and the increasing number of elderly people mean, older people face a variety of problems: changing health, past events and losses, narrowing of social ties, changes in social roles, negative social attitudes and personal characteristics. Old age is the last stage of a person's life, which is conducive to self-fulfilment and is synonymous with self-care, and it is important for a person to feel that his or her life still has a sense of purpose in order to live a more active and productive life, in a way that takes into account the person and the possibilities available to him or her. However, the implementation of this process is often limited by social isolation, health problems, economic difficulties, and age discrimination. Therefore, the work of social workers becomes not only a means of assistance, but also a means of empowerment, allowing older people to remain active, independent, and meaningful to society.

Keywords. Old people, self-fulfillment, social work, roles of a social worker.

Introduction

Data from the World Health Organization [14] show that in 2050, people aged 60 and older will make up 2.1 billion of the total population worldwide. According to data from the Official Statistics Portal [8], in 2023, people aged 65 and older accounted for 20% of the population of Lithuania (571,700), and since 2013, the number of elderly people has increased by as much as 5.4% (29,500). For older people, self-fulfillment takes on a specific meaning – it is associated with the ability to maintain dignity, participate in social life, pass on experience to the younger generation, continue favorite activities, or volunteer [5]. However, the implementation of this process is often limited by social isolation, health problems, economic difficulties, and age discrimination. Therefore, the work of social workers becomes not only a means of assistance, but also a means of empowerment, allowing older people to remain active, independent, and meaningful to society.

Social workers become an important link between individual needs, social structures, and the social services system, operating in various contexts—individual, group, and community. Therefore, it is necessary to reveal the roles that social workers perform and how these roles contribute to ensuring the self-realization of older people. Specialists help them to understand and accept the ageing process and its consequences in order to achieve positive ageing, developing the ability to use their time productively for self-realisation, maintaining emotional stability, inner cohesion, opportunities for personal development and a meaningful perception of life [7; 13; 9; 4]. It is not only the task of social workers, but also of society as a whole to provide older people with opportunities for self-realization, continuous personal development, and certain social commitments [2].

Research results show [13] that social work specialists involve elderly people in certain activities by applying selected professional roles. Professional roles can be applied in various capacities, such as teacher, listener, advisor, protector, etc. The socio-cultural activities organized are based on the social worker's empathy, friendliness, sincerity, and openness, while maintaining the principles of confidentiality.

Thus, social workers play an important role in encouraging older people to find purpose, meaning, and fulfillment in their lives. They provide social services and emotional support to help older adults discover their potential. Social workers can also organize activities that promote socialization, activity, and community involvement, thereby encouraging older adults to pursue meaningful goals and find meaning in life. Their role is important because they can help older people overcome challenges, solve problems, and enhance their self-esteem and quality of life.

Research objective. To reveal the roles of social workers in promoting self-realization among older people.

Research methods. Analysis of scientific literature, semi-structured interviews, qualitative content analysis.

Research methodology

Type of research. In order to reveal the roles of social workers in working with elderly people to achieve their self-realization, a qualitative data collection method was used, and the research method was a semi-structured interview. The basis of the research is focused on the views, personal attitudes, and everyday lives of the research participants [6].

Sample. The research sample was selected using precise selection criteria – social workers. Social workers working in nursing homes and social services day centers were selected and participated in the research. Six social workers working with elderly people participated in the research.

Research instrument. The semi-structured interview questions are divided into three categories. The first category consists of five questions focused on factors influencing self-actualization and the search for meaning in life among older adults. The second category consists of five questions aimed at revealing the sources of meaning in life for older people. The third category consists of six questions aimed at finding out about the role of social workers in promoting self-realization among older people. This article will present the results of the researc focused on the roles of social workers.

Research ethics. This research was conducted in accordance with the principles of research ethics: free choice to participate in the reseach, goodwill, and confidentiality.

Research results

Self-actualization in older adults. The results of the research revealed that self-actualization in older adults is a highly individual process that is directly related to a person's values. Self-realization can be influenced by one or more factors, such as finding and developing meaningful activities, maintaining close relationships, continuous improvement, involvement in the community, and continuing to engage in favorite activities in old age (see Table 1).

Table 1

Social worker's understanding of self-realization in old age among elderly people

Category	**Subcategory**
Factors influencing self-actualization in older adults	Meaningful activities
	Relationships with loved ones
	Knowledge
	Integration into the community
	Continuation of favorite activities in old age
	Individuality of self-realization
	The most important human values

The results of this research also showed that self-realization can be very diverse and understood differently. Self-realization manifests itself through a person's individuality and meaningful activities, relationships with loved ones, involvement in the community, continuing previously enjoyed activities, and acquiring new knowledge. In order to discover their own form of self-realization, older people must be influenced by their own level of motivation, personal characteristics, and values [1].

Profile of a social worker working with elderly people. The results of the research revealed three most important qualities of a social worker: empathy, patience, and sincerity. It was emphasized that a social worker must be able to approach each person, understand them, be attentive and flexible, taking each situation individually into account. In addition, one of the most important values of a social worker was identified – humanity (see Table 2).

Table 2

Profile of a social worker working with elderly people

Category	**Subcategory**
Personal characteristics	Empathy
	Patience
	Sincerity
Abilities	Ability to approach people
	Understanding
	Attentiveness
	Flexibility
Values	Humanity

Research by other authors shows that the most important aspect determining positive results is the social worker's abilities, giving hope, and creating opportunities in the life of an elderly person [10]. This research revealed the most important qualities of a social worker when working with older people: empathy, patience, sincerity, and other qualities. Other authors argue that social workers working with older people must be tolerant, patient, and compassionate, and able to devote a lot of attention and dedication [12]. This research highlighted the necessary skills of a social worker: the ability to approach people, listen and understand, be attentive and flexible. The most important value of a social worker – humanity – also stood out.

The roles of social workers in providing assistance to older people. The results highlighted three main roles: helper, motivator, and grandchild. However, other roles such as advocate, psychologist, and psychiatrist were also mentioned (see Table 3).

Table 3

Social worker assistance in the self-realization of elderly people

Category	Subcategory
Role in providing assistance	Helper
	Motivator
	The role of the "grandson"
	Other roles

A social worker is a specialist who performs various social work roles and, if necessary, is able to switch between them. A social worker must ensure the performance of mediation, counseling, and case management roles and, in doing so, helps older people to become involved in the community and realize themselves and their needs [13]. This research revealed three main roles of a social worker in providing assistance to older people: helper, motivator, and "grandchild." The roles of advocate, psychologist, and psychiatrist were also mentioned. Other authors argue that social workers become helpers who seek to reduce the anxiety experienced by older people and restore the balance of their internal resources [3; 13].

Challenges in communicating with elderly people about the meaning of life. The results of the research showed that conversations about the meaning of life depend on the social worker's attitude. Older people do not communicate directly with social workers about the meaning of life, and their communication is limited by their personal limitations (see Table 4).

Table 4

Challenges in communicating with elderly people about the meaning of life

Category	Subcategory
Communication challenges	Appropriate verbal expressions
	Indirect communication about meaning
	Limited opportunities for individuals to communicate

In this research, social workers shared certain situations of service recipients and the interventions applied. Social work is based on theories that focus on the practical application of social systems and personal behavior theories, carrying out interventions where the individual and the environment interact [13]. This reseach revealed individually tailored social worker interventions that were based on the analysis of service recipients, knowledge, assessment of available resources, and personal strengths. In order to ensure and implement interventions, it is necessary to know the person well as a whole [10]. This research also revealed changes in the interventions used. Interventions were carried out through occupational activities: involving elderly people in senior clubs, dancing, refreshing musical skills, refreshing favorite activities such as sewing, and inviting them to participate in organized occupational activities. The interventions successfully implemented by the social worker created opportunities for older people to actively engage in society, strengthen themselves physically and psychologically, open up to other people and new experiences, and rediscover long-forgotten activities. Other authors argue that social workers practicing gerontological social work must take into account the factors that complicate communication with older people [4].

This research revealed that the main challenges faced by social workers when working with older people are: the personal attitude of the social worker, when the worker feels that they know more than the service recipient. Indirect communication about meaning among older people – people are not inclined to communicate directly about the meaning of life and its importance. Limited communication opportunities due to certain diseases, syndromes, or other changes occurring during the aging process. Therefore, in order to achieve change in a person through social work, the efforts of the social worker alone are not enough. The importance of the social worker's attitude when working with older people is also revealed. Other authors argue that in order to achieve successful intervention, social workers must have a positive attitude towards older people and the ageing process itself [12].

Social worker assistance to a person who feels that life has lost its meaning. The results of the research revealed that social workers respond by being present, communicating, and trying to give hope to the elderly person. However, if the situation does not change, they cooperate with other specialists such as psychologists or other social workers. If the situation takes a turn for the worse, a chaplain is involved (see Table 5).

Table 5

Social worker assistance to a person who feels that life has lost its meaning

Category	Subcategory
Reactions to a person who has lost the meaning of life	Being there
	Communication
	Giving hope
Cooperation with other specialists	Psychologist
	Chaplain
	Other social worker

This research revealed social workers' reactions to individuals who feel they have lost the meaning of life. The reactions are based on individuality, taking into account the needs of the elderly person themselves. The following were identified: the social worker's presence, communication, and giving hope. Other authors argue that social work professionals who focus on service recipients as individuals should assess the individual's attitude and perspective on their personal situation during discussions with elderly people [11]. Other authors' studies have shown that the most important aspect determining positive results is the social worker's ability to communicate and establish mutual relationships with older people and to give them hope [10]. This research also revealed that social work is based on cooperation with specialists in other fields.

Improving social workers' competencies by enhancing their ability to help older people realize their potential. The results highlighted the following areas for competence improvement: communication skills training, organization of sociocultural activities, opportunities for applying innovations, changes in the health of older people, opportunities for successful aging, and other relevant training (see Table 6).

Table 6

Improving social workers' competencies by enhancing their ability to help older people realize their potential

Category	Subcategory
Areas for improving competencies	Communication skills training
	Organization of sociocultural activities
	Opportunities for applying innovations
	Health changes in older people
	Opportunities for successful aging
	Other relevant training

Social work is one of the professions based on continuous competence development, expansion of various knowledge, discovery of ways to express creativity, finding new and adapting already known work models, and the ability to adapt and ensure comprehensive preparation of specialists in this field in various situations [13]. This research revealed the need for social workers to acquire additional knowledge focused on the self-realization of older people and the discovery of meaning in life. It also highlighted the need to improve communication skills with older people, organize sociocultural activities, expand the range of activities, and develop competencies in engaging and motivating. Other authors reveal that social workers must have a good understanding of gerontology, the social and psychological processes of aging in society, and be familiar with human psychosocial development [12]. This research revealed that social workers need training on the most common diseases, syndromes, and disabilities in old age and how to manage them. Learn more about the theoretical and practical applications of successful aging and other psychology- or pedagogy-based training.

Conclusions

1. The roles of social workers focused on the self-realization of older people are multifaceted and include mediation, counseling, empowerment, advocacy, and community mobilization. These roles contribute to improving the quality of life of older people, strengthening their social participation and dignity. The process of self-actualization in old age depends not only on individual characteristics, but also on the social environment, so the activities of social workers must be directed both toward providing personal assistance and toward promoting community change.

2. Social workers play an important role in encouraging older people to find purpose, meaning, and . fulfillment in their lives. They provide social services and emotional support to help older adults realize their potential. Social workers can also organize activities that promote socialization, activity, and community involvement, thereby encouraging older adults to pursue meaningful goals and find meaning in life. Their role is important because they help older people reveal their unique autobiography, the most important themes of their lives, thus conveying and emphasizing their agency. In various situations, social workers become assistants, consultants, intermediaries, and enablers, seeking to reduce the anxiety experienced by older people, restore their inner resources, and reestablish their balance. The research confirmed the importance of these roles and revealed a new role for social workers—that of a "grandchild" who creates a personal connection with an elderly person and helps to transform past grievances into a feeling of hope.

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TECHNICAL SCIENCES

MARINE LOGISTICS IN THE INTERNATIONAL GRAIN TRADE: TECHNICAL, COMMERCIAL AND LEGAL ASPECTS

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Abstract

The article analyses marine logistics in the international grain trade as an integrated system of commercial, technical, and legal processes. Given that over 90% of global grain exports move by sea, the study emphasises the sector's strategic importance for food security and market stability. The commercial section examines the contractual structure of grain transactions, the role of intermediary traders, and the practical implications of **FOB** and **CIF** terms. The technical overview discusses bulk carrier classes, cargo conditioning, and modern methods for quantity and quality control. The legal analysis focuses on the Bill of Lading as both a transport and financial instrument, alongside the transition to electronic documentation. The study concludes that efficiency in grain logistics requires coordinated integration of technology, optimised contractual frameworks, and advanced port infrastructure.

Keywords: Marine logistics; grain trade; FOB; CIF; bulk carriers; Draft Survey; port infrastructure; Bill of Lading; electronic bills of lading; maritime law; documentary credit; cargo quality control; digitalisation in shipping.

1. Introduction

International grain trade is a strategic segment of the global economy, closely linked to food security and price stability in agricultural markets. Dimitrakieva, S., Kostadinov, O.D., Atanasova, K. (2021). Due to the large volumes and the geographic distribution of producers and consumers, more than 90% of international grain exchange is carried out by sea. This makes marine logistics a critical component of supply chains. [1] Grain as cargo is sensitive to moisture, temperature, and duration of transport, which requires strict technical, organisational, and legal standards.

As **Kostadinov, O. D. (2021).** emphasises, "*the sustainability of grain supply chains depends on the precise interaction between technical solutions in fleet operation, the commercial architecture of contracts, and the regulatory framework of international maritime law.*" In this context, the present article aims to systematise and analyse the main commercial, technical, and legal aspects of marine logistics in the grain trade, providing an integrated analytical perspective on the process. [2]

2. Commercial Aspects

2.1. Commercial Architecture and the Role of the Intermediary Trader

Kostadinov, O. D. (2024). The commercial architecture of international grain trade is characterised by a multi-layered chain of participants: producers, local exporters, global traders, shipowners, charterers, carriers, port operators, insurers, and banks. In many cases, an intermediary international trader purchases the cargo from the exporter under FOB terms and resells it to the final buyer under CIF terms. [3] In this way, the trader assumes responsibility for organising maritime transport, insurance, and the documentary chain, monetising the price difference as well as their expertise in managing logistics and financial risk.

Kostadinov, O. D. (2024). Notes that the intermediary trader functions as a coordinator of "overlapping contractual layers"—sales contracts, charter party agreements, insurance policies, and letter-of-credit arrangements. Successful synchronisation of these contracts is crucial to preventing delays, claims, and financial losses. [3] Thus, the commercial architecture is not merely a sequence of transactions but an integrated system where logistics and finance are deeply interwoven.

2.2. Comparative Analysis of FOB and CIF

FOB and CIF are the dominant terms in grain trade. **Kostadinov, O. D. (2021).** Under FOB, the seller is responsible until the goods cross the ship's rail at the loading port. The buyer organises maritime transport, insurance, and assumes all subsequent risks. Under CIF, the seller must arrange transport to the discharge port, secure insurance, and provide the buyer with the required documents—bill of lading, insurance policy, and commercial invoice. [4] This transfers significant logistical responsibility to the seller.

Table 1. Key Differences Between FOB and CIF in Grain Trade:

Indicator | FOB | CIF

Transport organisation | Buyer charters the vessel | Seller arranges transport

Insurance | Buyer responsibility | Seller obligation

Risk transfer | Upon loading on board the vessel | At the discharge port

Documentary obligations | Limited | Full set of documents under letter of credit

Figure 1 (fig.1) illustrates the steady global expansion of maritime grain transport, driven by rising trade volumes and the centralisation of supply chains around seaborne logistics. The upward trend underscores the growing strategic importance of bulk carriers and port

capacity in maintaining reliable grain flows. Overall, the figure highlights how maritime transport has become a structural pillar of international grain trade.

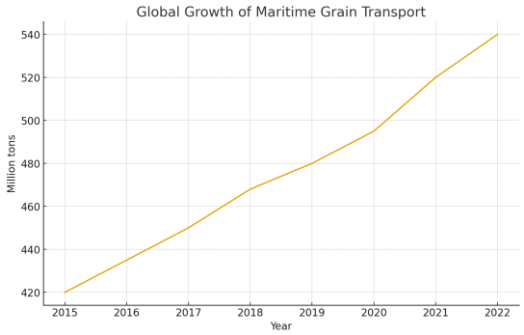

Figure 1. Global Growth of Maritime Grain Transport

3. Technical Aspects

3.1. Bulk Carrier Vessels and Their Classes

(UNCTAD, 2022) "Bulk carriers are purpose-built vessels designed to transport unpackaged dry cargoes such as coal, grain and iron ore. They vary significantly in size, from Handysize to Capesize, each segment serving different trade routes and port constraints." [5]

(Stopford, 2009) "Bulk carriers developed into a range of standardized sizes such as Handymax, Panamax and Capesize, each suited to particular loading facilities, canals and ocean routes. Their configuration with large box-shaped holds and minimal internal structures is optimized for the efficient carriage of dry bulk commodities." [6]

Bulk carriers are specifically designed for the transport of bulk cargoes, including grain, ore, and coal. They are equipped with large holds, minimal bulkheads, and systems for safe loading and unloading. Depending on deadweight and dimensions, bulk carriers are classified as Handymax, Supramax, Panamax, and Capesize (fig.2). Each class corresponds to certain trade routes and port limitations. For example, Panamax vessels are optimised for transit through the Panama Canal, while Capesize vessels serve long oceanic routes.

According to **Kostadinov, O. D. (2021),** "the technical suitability of bulk carrier vessels for grain cargoes is determined not only by their carrying capacity but also by the ability to control microclimate in the holds, the efficiency of ventilation systems and vessel stability under variable loads." [2]

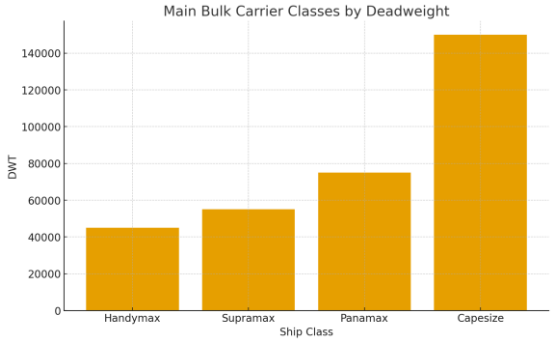

Figure 2. Main Bulk Carrier Classes by Deadweight

3.2. Control of Quantity and Quality

Quantity control during loading and discharge is typically performed using the Draft Survey method—based on measuring the vessel's draft before and after operations and using hydrostatic tables. The involvement of independent surveyors increases trust between parties and reduces the likelihood of disputes. Additionally, samples are taken for laboratory analysis to assess moisture, impurities, and other quality indicators. These parameters directly affect price and acceptance of the cargo by the buyer.

(Food and Agriculture Organization, 2011) "Temperature and moisture content are the primary factors influencing the safe storage and transport of grain, and continuous monitoring is essential to prevent deterioration and self-heating." [7]

Technological progress has led to the implementation of systems for continuous monitoring of temperature and humidity in the holds, with digital twins used in some cases to model cargo behaviour during the voyage. This contributes to better risk management regarding self-heating and deterioration of quality.

4. Port Infrastructure and Logistics Hubs

4.1. Grain Terminals and Intermodal Connections

Kostadinov, O. D. (2022). Grain terminals in major seaports function as high-tech logistics hubs. They integrate silo complexes, high-capacity conveyor lines, weighing systems, analytical laboratories, and intermodal connections to the rail and road network. [8]. Their objective is to ensure a fast, safe, and transparent flow of goods from inland areas to the vessel and vice versa.

Kostadinov, O. D. (2022). Emphasises that "the efficiency of port operations determines the real throughput capacity of global grain supply chains." [8] Congestion, limited capacity, or outdated equipment increase vessel laytime, generate demurrage charges, and increase costs for all participants.

Figure 3 (fig.3) demonstrates the significant variations in storage and handling capacity across major grain terminals, highlighting the unequal distribution of logistical capabilities in global trade routes. These differences directly influence vessel turnaround times, congestion risks, and the overall efficiency of maritime grain supply chains. The figure reinforces the article's conclusion that modern, high-capacity terminals play a decisive role in sustaining stable and competitive grain logistics.

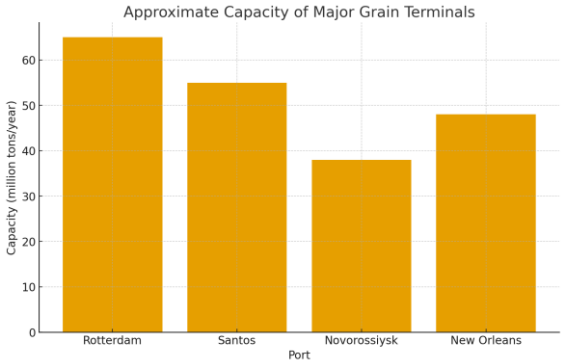

Figure 3. Approximate Capacity of Major Grain Terminals

5. Legal Aspects and Documentary Security

5.1. The Bill of Lading as a Legal and Commercial Instrument

The Bill of Lading (B/L) is the central document in maritime grain transport. It performs three functions: evidence of the contract of carriage, receipt for the cargo, and document of title. Banking practice under documentary letters of credit requires the presentation of a clean bill of lading—without remarks regarding cargo condition. Any such remark may result in refusal of payment under the credit.

According to Kostadinov, O. D. (2024), the bill of lading represents "*the legal bridge between the logistical reality of the cargo and the financial infrastructure of the transaction.*" [3] When issued under a charter party, it may create an independent legal relationship between the carrier and the rightful holder of the document, separate from the charter party itself.

5.2. Digitalisation and Electronic Documents

Tikaradze, G, Kostadinov, O. D. Modern practice is gradually transitioning to electronic bills of lading (e-BL) and digital platforms for managing documentary flows. Technologies such as blockchain allow full traceability of documents and significantly reduce the risk of fraud and duplication. [9]

Digitalisation also raises new legal questions—related to the evidentiary value of electronic documents, applicable law, and jurisdiction in cross-border disputes. Nevertheless, the trend is clear: marine logistics and grain trade increasingly rely on integrated information systems supporting both operational and legal processes. *(IMO, 2016)* "*Establishing a recognized set of features for using electronic certificates should help alleviate problems inherent in reliance on paper.*" [10]

6. Conclusion

Marine logistics in the international grain trade is a complex system of interconnected commercial, technical, and legal elements. Successful functioning of this system requires high-level coordination between contractual mechanisms, technical fleet operations, port infrastructure, and a predictable legal framework. The analytical approach presented in Kostadinov's research shows that sustainable development of grain logistics can be achieved through the integration of modern technologies, optimised contractual schemes, and digitalised documentary processes. This creates conditions for higher efficiency, reduced risks, and improved global food security.

7.Recommendation

Based on the commercial, technical, and legal analysis presented in this study, several key recommendations can be formulated to improve the efficiency, resilience, and legal predictability of marine logistics in the international grain trade:

7.1.Strengthening contractual integration and standardisation.

Parties involved in grain logistics should adopt harmonised contractual frameworks, ensuring consistency between sales contracts, charter parties, insurance policies, and documentary credit requirements. The use of standardised clauses—especially for demurrage, laytime, liability allocation, and documentary obligations—reduces ambiguity and minimises the potential for disputes.

7.2. Investing in modern fleet technologies and cargo-condition monitoring systems. Shipowners operating bulk carriers in grain trades should implement advanced ventilation, temperature, and humidity monitoring systems, including digital twin technologies. These systems enhance cargo preservation, reduce risks of self-heating or quality

degradation, and support data-driven decision-making during the voyage.

7.3. Expanding and upgrading grain terminal infrastructure.

Port authorities and terminal operators should focus on improving intermodal connectivity, increasing silo capacity, modernising conveyor systems, and integrating real-time operational control systems. These investments shorten vessel turnaround times, reduce demurrage exposure, and increase the reliability of global grain supply chains.

7.4. Enhancing digitalisation of documentary processes.

Stakeholders should accelerate the adoption of electronic bills of lading (e-BLs) and blockchain-based document management platforms. Digital workflows reduce administrative delays, enhance security against fraud, and improve transparency across the entire supply chain. Regulatory bodies should also provide clear rules on the legal validity and evidentiary force of electronic documents.

7.5. Improving risk-management strategies.

Traders, carriers, and insurers should adopt integrated risk-assessment models, considering technical vessel capabilities, weather patterns, port congestion indices, and market volatility indicators such as BDI movements. Proactive risk identification enables more accurate freight planning and optimisation of transport costs.

7.6. Establishing training programmes for maritime and logistics professionals. Given the complexity of modern grain logistics, targeted training in contract management, maritime law, cargo-handling technologies, and digital documentary systems is essential. Capacity building contributes to fewer operational errors, higher legal compliance, and more efficient supply-chain coordination.

7.7. Encouraging international cooperation and regulatory harmonisation. International organisations, port administrations, and national maritime authorities should work toward the harmonisation of regulations governing grain transport, electronic documentation, and port operations. Coordinated rules facilitate smoother trade flows and reduce inconsistencies that may impede logistics performance.

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Anschrift: Industriestraße 8,74589 Satteldorf Deutschland.

E-mail: info@dizzw.com
WWW: www.dizzw.com

Chefredakeur: Reinhardt Roth

Druck: Einzelfirma Artmedia24, Industriestraße 8,74589 Satteldorf Deutschland

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Address: Industriestrasse 8,74589 Satteldorf Germany.

E-mail: info@dizzw.com
WWW: www.dizzw.com

Editor in chief: Reinhardt Roth

Printing: Artmedia24, Industriestrasse 8,74589 Satteldorf Germany.

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ISSN (Print) 2701-8369

ISSN (Online) 2701-8377

Edition: № 118/2025 (December) – 118th

Passed in press in December 2025

Printed in December , 2025

Printing: Artmedia 24, Industriestrasse 8,

74589 Satteldorf, Germany.

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